ASPHALTS

Their Sources and Utilizations

Asphalt for

DUSTLESS ROADS

Recent Improvements in Asphalt Industries

Together with Addenda
Treating on General Waterproof Construction

BY

T. HUGH BOORMAN
Civic Engineer and Asphalt Expert

NEW YORK
WILLIAM T. COMSTOCK
1908

CONTENTS

PREFACE

THIS book was suggested by a series of articles that appeared some time since in *Architects' and Builders' Magazine*. Since the numbers containing these articles ran out of print, there has been a continuous call for them, and the request was made that they be issued in book form.

The great advance of late in the asphalt industry has called for a complete manual on the subject. This the author has endeavored to furnish, so that architects, engineers and students in the technical schools and municipal officers having charge of road construction may have a reliable reference book on the subject.

As will be seen, many new features in the exploitation and utilization of asphalt have arisen during the first eight years of this century, and undoubtedly the greatest demand yet known is still to come for the purpose of surfacing dustless roads. This line of work is very fully treated of, and, to the author's mind, is the question of the day.

I have endeavored, without fear or favor, to give credit to all producers of asphalt in every country and clime and to give to all their due. I have made no comparisons of asphalts as against other materials, although some of my sources of information may have incidentally given statements showing the superiority of asphalt over other materials for waterproofing, etc.

This book is the result of thirty-six years of active life among asphalt mine owners, refiners, importers, exporters, manufacturers and contractors, and, as will be seen, has taken me to many countries, in all of which I have endeavored to glean information from all interested, from presidents of corporations to the humblest stirrer of an asphalt kettle.

To give due credit to all to whom I am indebted for information would well nigh call for an additional volume. At the risk of seeming ungrateful to the many, I wish to record special obligations to the late Leon Malo, C. E., and his coadjutor W. H. Delano, C. E., to the "Good Roads Magazine," "Municipal Engineering," and other technical journals; principally to the efficient, painstaking officials of the Bureau of Public Roads of the Department of Agriculture, whose work in helping the people of the United States to utilize their opportunites for building "good roads" in the various sections of the country cannot be too highly spoken of; and last, but not least, to my worthy publisher, W. T. Comstock, and to my son, Kitchell Monckton Boorman.

59 Pearl Street,
New York, *Sept. 14, 1908.*

T. HUGH BOORMAN

ASPHALT'S SOLILOQUY.

Although with pedigree somewhat mixed,
  And habitation scattered wide,
My place in civilization is fixed,
  With my virtue and purity tried.

Engineers are sounding my praise,
  Manufacturers and artists as well,
The scientist seeks thro' devious ways,
  But pronounces me "clear as a bell."

I am elastic, vivacious, tenacious,
  Impervious to weather and frost,
In purity non-imitatious,
  And always worth what I cost.

For an hundred uses bespoken,
  I am seized with ruthless hands,
My continuity is broken,
  And I'm labeled with many brands.

I bare my breast to your feet
  And cover the roof o'er your head,
Dry the walls from cellar to garret complete
  Then polish the shoes you tread.

Thro' me your body's protected,
  Your clothing made warm and dry,
And my coat, if not rejected,
  Will preserve you for years, when you die.

I stop the noise from the street, so appalling;
  Increase the real value on roads,
Prevent dumb brutes from slipping and falling,
  While they draw much heavier loads.

I protect magazines, reservoirs and vats,
  Am used in covering electrical cables,
Preserve cold storage from vermin and rats,
  Am useful in hospitals, breweries and stables.

In waterproof paper and felt,
  In the rubber you wear on your feet,
In stopping the jar where blows are dealt,
  In calking the seams of a fleet.

In varnish I am quite up to date,
  In pavements I stand at the head,
In paint I am a victim of fate,
  As Black is a sign of the dead.

—W. S. Godwin, of the Texas Co.

Chapter I.

DISCOVERY AND EARLY USE OF ASPHALT.

CONSIDERING the importance of the subject little has been published in regard to the material known by the generic name of asphalt. A few books and many short papers read before engineering societies, prepared for technical journals or for the circulars of asphalt companies, comprise, generally speaking, the literature on the subject. These have been written almost exclusively by engineers in the employ of special companies or others financially interested in particular asphalt deposits or mines, and so necessarily have dealt with the subject within a much confined limit.

It is proposed in this book to discuss the various kinds of asphalt and their adaptability for different methods of construction. In the first place all disputes on the nomenclature of asphalts must be avoided and the fact conceded that the hydro-carbons, viz., asphalt, bitumen, and maltha, are synonymous, while differing in chemical composition. I am the more anxious to take this ground, as in going back to the earliest times in which asphalt is known to have been used it is necessary to refer to the mineral pitch, or bitumen, as being the material quoted. The first use of asphalt spoken of was the cementing in the erection of the Tower of Babel; next we read that Noah pitched the Ark within and without, "bituminabis cum bitumine," says the Vulgate, and also in Genesis we read, "Et asphaltus fuit eis vice cimenti." The great law-giver, Moses, was preserved from death at the suggestion of the Egyptian Princess, in a basket rendered waterproof by bitumen.

Felltham wrote in the beginning of the 17th century of the "Bituminated walls of Babylon;" the source of its supply, the fountains of Is, on a tributary of the Euphrates, still yields asphalt.

Xenophon in his Anabasis speaks of the Median Wall as being

built of "Burnt brick laid in asphalt." Diodorus Siculus describes the process of laying the walls of Nineveh with material from the same source. He says: "In order to bind the bricks they were covered with a layer of asphalt, instead of simple tempered clay, and were arranged in courses, and between each thirteenth course a bed of reed canes was introduced." Diderot's Encyclopedia attributes the burning of Sodom and Gomorrah to the accidental ignition of petroleum or bitumen, but the word petroleum not having been known to ancient writers, the legend probably refers to maltha or bitumen. Other ancient authors mentioning asphalt were Herodotus, Aristotle, Strabo, Pliny and Homer.

The Egyptians made extensive use of bitumen; it was spread upon the bandages wound around their mummies, and its wonderful preservative properties can be seen in our museums, where so many of their illustrous dead now have their abiding place. Asphalt was also used by the Egyptians in the foundations of the Pyramids, and for the coating of the external and internal walls of the ground floors of houses, and in the construction of cisterns, silos and other work where waterproofing was necessary. Therefore, from before the time of the Deluge, asphalt has been used and referred to, and it is no new subject to be considered.

During the Middle Ages we read nothing of its use, and not until 1721 do we hear of a treatise on asphalt being written by Eyrini d' Eyrinis, professor of Greek, doctor of medicine, in which he wrote in a half serious, half-humorous manner of its uses for building purposes, and claimed it as a panacea for almost every sickness. This treatise, I understand, was reprinted by M. Leon Malo, C. E., the most able exponent of the Rock Asphalt industry, and to whose works I shall have to refer frequently.

The asphalt beds, or mine, which were discovered by Dr. d'Eyrinis in 1710 were those of the Val de Travers, in the Canton of Neuchatel. The doctor recommends the material, describing it as "Peculiarly suitable for covering all kinds of construction, to protect wood and stone work against decay, worms and the ravages of time, rendering them almost indestructible, even when exposed to wind, wet and extreme variations of temperature."

d'Eyrinis succeeded in using it with good effect for the lining of cisterns and walls, as a cementing material, and for the flooring of warehouses, etc.

After some time the material fell into disuse; the quarries of

"THE PLAZA," 59TH STREET AND 5TH AVENUE, NEW YORK.
Laid with Seyssel Rock Asphalt by T. Hugh Boorman, October, 1898.

Val de Travers were even forgotten, and it was not till the year 1832 that the material was again prominently and successfully reintroduced; the credit on this occasion being given to the Count Sassenay, and in 1838 the first asphalt sidewalks were laid in Paris. The rock asphalt seems to have been used in its mastic form for sidewalks and floorwork up to the year 1854, when M. Vaudry laid the first compressed rock asphalt roadway in Paris. The earliest knowledge of the adaptability of asphalt for this purpose seems, from M. Malo's account, due to the perspicuity of a Swiss engineer, M. Mérian, who, in 1849, found that in summer the pieces of rock that fell from the carts in traversing the road between the mine and the mastic works at the village of Travers compressed under the wheels; he put this lesson to profit by constructing a macadam road of crude rock asphalt, which was compacted with a roller. In spite of the instability of its foundation and the irregularity of its maintenance the road was reported by M. Malo as in good order in 1866.

From the Rock Asphalt Mines, therefore, it may be considered that there was started the great industry of asphalt street pavements, which add so much to the appearance and health of our modern cities. Under these circumstances it seems only right to first take up the subject of Natural Rock Asphalt. It was, I believe, first brought prominently before the notice of the American Engineers by Mr. Edward P. North, C. E., who, in a paper read on April 16, 1879, before the American Society of Civil Engineers, on "The Construction and Maintenance of Roads," gave his impression from observation and information acquired by him on the subject of asphalt streets in London and Paris.

Compressed Neuchatel rock asphalt was, however, laid in New York, in Union Square, in 1872, the writer having taken part in the actual work of laying it. This pavement, however, owing to a lack of heavy traffic, did not prove a success, and some ten years later it was replaced with asphalt mastic, which was partly manufactured from the old rock pavement. The original company laying the work became financially embarrassed and went into the hands of receivers, and it was under orders of the latter that four blocks of Natural Rock Asphalt streets were laid on Pennsylvania avenue, Washington, with Neuchatel rock in 1876. This pavement, however, not having any company to look after its maintenance, was repaired with Trinidad asphalt mixture, with which material eventually it was entirely resurfaced.

Three or four years later the Neuchatel Asphalt Company, of London, owners of the Val de Travers' concession, sent over as their representative the late Captain Henry R. Bradbury, who supervised the laying of Neuchatel rock pavement in front of the Brevoort House and Hotel Victoria, on Fifth avenue, New York; his successor in the American management, Mr. Robert Butcher, found that the prices attainable for the work here did not compare favorably with those obtained in European cities, and has not followed up street pavement work.

In 1892 the Compagnie Générale des Asphalte de France established a model rock asphalt plant at Long Island City, and under the management of the author from 1895 to 1900 some 28,000 square yards of compressed asphalt were laid in New York, and about 15,000 square yards in Brooklyn. During this period a large amount of rock asphalt was also supplied from the Seyssel and Ragusa mines for use on streets in Philadelphia, Boston and Montreal.

The generally recognized standard European rock asphalts are those of Seyssel, in the Department of Ain, France, and the Val de Travers, in the Canton of Neuchatel, Switzerland. Important deposits are now being operated at Ragusa, Sicily; four companies are working adjacent mines, viz.: The Val de Travers Asphalt Paving of London, the United Limmer & Vorvohle Rock Asphalt Co., the Societa Sicula per L'Explotazione Dell Asfalta Naturale Sicilians, Palermo, and H. & A. B. Aveline Catania, exporting large quantities to Europe and America, their shipping ports being Mazzarelli, Syracuse and Catania—other deposits are found at Mons, Department of Gard, France; Lobsann, in Alsace; Limmer, near Hanover, Germany; San Valentino, Province of Chieti, Italy; Maestu, in Spain, and in several parts of the United States, which, of late, having become quite an important feature in the asphalt industry, will be considered in full in a subsequent chapter. Mr. W. H. Delano, of Paris, in his "Twenty Years' Practical Experience of Natural Asphalt and Mineral Bitumen," published in 1893, gives the analysis of natural rock asphalt as follows: As mined, the rock should be of a chocolate color, fine in grain, evenly impregnated with bitumen, free from sulphur, pyrites, clay, sand and of other extraneous matter. When examining with microscope always look at a fresh fracture. Rich Val de Travers rock, containing, say 11 to 13 per cent. bitumen, should be mixed with equal

LAYING SEYSSEL ASPHALT MASTIC, CENTRAL PARK AND 59TH STREET, IN 1883.
By New York Mastic Works. E. H. Wootton and T. Hugh Boorman.

parts of fine Seyssel rock containing 7 per cent. of bitumen, which is fixed and invariable, producing thus:

$$\frac{11 + 7}{2} = 9$$ per cent. powder, suitable for a climate like that of London. The same may be done with Ragusa (Sicilian rock), which is rich in bitumen of excellent quality, only the texture or grain of the limestone is loose, whereas that of Seyssel is fine and dense. Mons and St. Jean de Marejols asphalts are similar in structure to Ragusa, but the limestone is much finer.

The rough and ready way of testing rock asphalt is to dissolve a sample of its powder taken from three-ton bulk, in carbon bisulphide, turpentine, or ether. After stirring this well with a glass rod, strain it through a thick paper filter; then let the sulphide evaporate, which it will do at 70 degrees; weigh the bitumen and the residuum, afterwards washing the latter in hydrochloric acid, which will cause the lime to effervesce, leaving any residue of silica, pyrites, etc.; but for an absolute test an analyst accustomed to hydro-carbons should be called in.

In connection with this the following tables, showing the comparative analyses of asphalts, are given on the next page. They were prepared by Col. James W. Howard, B. L., C. E.

The rock asphalt industry may be divided into two branches. The "comprimé," or compressed work, and the "coulé," or mastic work. For streets the compressed asphalt is used. The rock in its crude condition is placed in a crusher and reduced to small pieces and then passed through a disintegrater and reduced to a powder; it then passes through a twenty-mesh sieve, nothing being added to or taken from the powder obtained by grinding the bituminous rock. The powder should contain not less than 9 per cent. of natural bitumen. The powder is then heated in a suitable apparatus to 200 degress to 250 degrees Fahrenheit, and must be brought to the street at a temperature of not lss than 180 degrees Fahrenheit in carts made for the purpose, and carefully spread to such depth that after having received its ultimate compression it will have a thickness of two inches. The surface is rendered perfectly even by tamping, smoothing and rolling with heated appliances of approved design. This surface should invariably be laid on a foundation of six inches of Portland cement concrete.

TABLE I.

ANALYSES OF CRUDE ASPHALTUM FROM A FEW COUNTRIES, ETC.

	California.	Cuba.	Mexico.	Trinidad.	Venezuela.
Bitumen	38 to 85%	24 to 68%	35 to 94%	35 to 40%	45 to 95%
Mineral matter	60 to 8	73 to 26	55 to 4	41 to 26	40 to 2
Organic matter.....	1	2 to 1	8 to 2	10 to 4	7 to 1
Water	2 to 6	1 to 5	2	14 to 30	8 to 2
Total per cent...	100% 100%	100% 100%	100% 100%	100% 100%	100% 100%

ANALYSES OF ASPHALT ROCK FROM A FEW COUNTRIES, ETC.

	California. Various. %	Indian Ter. Various. %	Kentucky. Various. %	Texas. Various. %	Utah. Various. %
Bitumen	6.47 to 29.60	3.0 to 12.30	4. to 10.70	3.11 to 11.65	6.34 to 36.28
Calcium Carbonate	9.10	80.00	....	90.30 to 0.03	8.02 to 29.52
Silica	89.73 to 45.40	96.90 to 4.43	95.63 to 89.30	88.82	82.87 to 6.46
Alumina, etc.....	15.90	0.10 to 1.11	....	6.0	27.74
Magnesium carbonate	....	1.86	....	0.3	....
Miscellaneous ...	3.80	0.30	0.37	0.29	2.77
Total per cent....	100% 100%	100% 100%	100% 100%	100% 100%	100% 100%

J. W. HOWARD, B. L., C. E.

TABLE II.

*CLASSIFICATION AND LOCATION OF CERTAIN IMPORTANT BITUMENS AND COMPOUNDS.

GLANCE-PITCH, ASPHALTUM, MALTHA.		ASPHALT AND BITUMINOUS ROCK.	
Pure or Nearly Pure (with Small Per Cent. of Mineral and Organic Matter).	Compounded with Earthy Matter (Large Per Cent. of Silicates, Alumina, etc.).	Compounded with Limestone (Containing Silicates, etc.).	Compounded with Sandstone (Containing Carbonate of Lime, etc.).
Argentina.	Argentina.	Austria.	France.
Barbadoes.	Australia.	Cuba.	Germany.
China.	Barbadoes.	France.	Italy.
Cuba.	China.	Germany.	Russia.
Egypt.	Colombia.	Hungary.	Sicily.
Equador.	Cuba.	Italy.	Spain.
Honduras.	Egypt.	Russia.	Turkey.
Japan.	Equador.	Sicily.	United States.
Mexico.	France.	Spain.	
Russia.	Germany.	Switzerland.	
Syria.	Honduras.	Turkey.	
Turkey.	Japan.	United States.	
United States.	Mexico.		
Venezuela.	Peru.		
	Russia.		
	Syria.		
	Trinidad.		
	Turkey.		
	United States.		
	Venezuela.		

*From Paper on "ASPHALTUM" by J. W. Howard of New York, at convention of the American Society of Municipal Engineers.

CHAPTER II.

ROCK ASPHALT MASTIC OR ASPHALT COULE.

ROCK asphalt mastic, or asphalt coulé, as it should more properly be called, forms a most important branch of the asphalt industry, Dr. d'Eyrinis was its first exponent, and so far as I know Dr. Jeno Kovacs the last, the latter, in his report on asphalt read in 1901 before the Budapest congress of the "International Association for the Testing of Materials." The term mastic I must state is most misleading, and I fail to find how the term originated. The word is French, not English. The Anglican noun "mastic" distinctly applies to the resinous substance obtained from the mastic tree, or to a kind of mortar composed of finely-ground oolitic limestone mixed with sand and litharge and used with a considerable portion of linseed oil; hence frequent confusion when the word mastic is used in specifications. The French word "mastic" is used for cement, and is more applicable. Still, with the innumerable cements used in construction, it would seem better to refer to coulé, or melted asphalt, when speaking of the use of asphalt in other than its powdered form. The preparation of asphalt coulé is as follows:

The rock, after being reduced to a powder, is placed in cylindrical kettles, in which about 8 per cent. of Trinidad asphalt has previously been placed and melted. The mass is stirred by revolving arms and agitators at a temperature of about 350 degrees F. for about nine hours. It is thus thoroughly "cooked," and is then run out of the kettles into moulds, where it cools in the form of cakes or blocks, weighing from 56 to 60 pounds each. These are stamped with the brands of the mines. The mastic so prepared should show an analysis about as follows:

Bitmumen	14.50	per cent.
Carbonate of lime	85.00	" "
Silica, alumina and oxide of iron.	.50	" "
	100.00	

To use it for walks or floors the blocks are broken up and again heated in suitable kettles and mixed with fine gravel or sand and Trinidad in the following proportions:

Mastic blocks (broken)	60	lbs.
Trinidad asphalt	4	"
Fine gravel and sand	36	"
	100	

This is "cooked" for about five hours at a temperature of about 360 degrees F., great care being taken constantly to stir the mixture. It is then taken out of the kettle by the bucketful and poured on the foundation prepared, its consistency being such that it will flow very slowly. It is then spread by means of wooden trowels and compressed and smoothed by rubbing, as in plastering. Soon after the introduction of asphalt coulé in Paris it was introduced into the United States by a Philadelphia architect. The floors of the portico of the old Philadelphia Merchants' Exchange were laid with it about the year 1838, as stated by me in my paper on "Asphalt in Building Construction," read before the Brooklyn Architectural Students' League,, May 14, 1890. Subsequently the War Department imported the material for covering the arches over casements and magazines in some of the forts, of which Fort William, on Governor's Island, was one. The great fire in Boston in 1872 first drew my attention to the desirable qualities of asphalt as a fireproof covering for roofs, and I introduced its use there in 1873. That this material is a most effective fireproof protection should be recognized.

In 1835 a number of the inhabitants of the city of Bordeaux certified that at the time of the conflagration of the Bazaar Bordelais, which happened on December 28th of that year, a number of burning beams, rafters and other bodies in flames fell on that part of the building covered with asphalt without causing it to melt, and further attested that the said roof so covered had not been injured to any material degree. Of the great fire in Hamburg in 1842, which destroyed, with other buildings, the Church of St. Nicholas, the London "Times" of the 28th of May of that year, said:

"It was remarked as a singular circumstance during the conflagration that roofs covered with asphalt, of which there are some here, opposed rather than encouraged the progress of the flames.

CITY HALL, PHILADELPHIA.
Roofs and corridors laid with Asphalt Coulé by The Vulcanite Paving Company.

It was imagined on account of the substance of which these roofs were composed that they would easily catch fire and be the cause of great mischief. Such, however, was not the case, for it appears that the fire had little or no effect on them, and when the roofs of the houses fell in, the asphalte, in which a sort of rubble is mixed up, was found to have resisted the effects of the heat, and, like a mass of dirt, served rather to smother the flames than to give them increased vitality."

Very exhaustive tests were made for The Omnibus Co. of Paris in 1868 by MM. Flachat and Noissette, who submitted the results to the French Society of Civil Engineers. The insurance companies in the United States give special rates where asphalt is used for roofs.

The specifications usually read:

"For roofs on concrete foundations properly leveled and graded, lay one inch of Seyssel or Neuchatel rock asphalt mastic, applied in two coats, on three thicknesses of roofing felt cemented with asphalt."

Copper flashing should always be specified in connection with this roofing. The roof of the Philadelphia City Hall was laid by the Vulcanite Paving Co. with asphalt mastic, and the same material was used in the corridors of the building. The use of asphalt coulé is by no means confined to roofs; it is a desirable material for construction, from the damp course in the foundation of a building to the roof on the top of the same. Used as a damp course in the foundation, it arrests absolutely the capillary attraction that is so fatal to many buildings and renders them unhealthy through dampness. Cellars should be floored with asphalt so as to insure dryness and health.

As flooring for use in hospitals, lavatories, laboratories, laundries, refineries and mills it stands without a peer. It is impenetrable by moisture ,and will not crack from settlement of masonry, as will rigid and unyielding substance like artificial stone made from cement. Its characteristic of elasticity allows it to take up the varying strains and settlements that will occur in any masonry without cracking. Used as a foundation under heavy machinery, it absorbs all vibration and makes possible the mounting of the heaviest machinery in closely crowded quarters. As a flooring for railway stations, it will stand without cracking or splitting the impact of heavy blows from the dropping of baggage; it is not slip-

pery, and can be laid in a monoltihic sheet without joints, which cannot be said of artifical stone. It is particularly recommended for breweries, paper mills, pulp mills, laundries and other floor surfaces, which from the nature of the business are frequently wet and covered with water. It will not rot; it has no joints; no water can leak through to damage ceilings or goods stored in lower floors.

Under usual circumstances one inch of asphalt mastic will stand any ordinary traffic. In exceptional cases, however, such as in wash houses and racking cellars of breweries, a thickness of one and a half to two inches is advisable.

For cellars and floors for light business purposes three-quarters of an inch will suffice.

Asphalt floors are preferably laid on concrete three inches thick, or in case of fireproof construction of hollow brick arches concrete leveled off about half an inch above the iron beams. Still, asphalt can be laid with advantage on wooden floors, in which case felt paper is laid on the boards to prevent any trouble from warping of the wood. One of the largest fields for the use of asphalt coulé is for park walks. For nearly a quarter of a century the Park Department of New York has used this description of pavement, and with the exception of Madison Square, every park from the Battery to St. Mary's, in the Bronx, has had almost its entire walk areas finished with an asphalt surface.

In view of the satisfaction that this work has given, it may be well to give the specification prepared by the department engineer, who, after calling for a foundation of three inches of Portland cement concrete, says:

"After the base has been prepared as specified, and with its surface clean and dry, a layer of Seyssel or Mons, Neuchatel, Sicilian or Limmer asphalt mastic, in no place less than one inch in thickness, after having received its ultimate compression, is to be placed upon the base, carefully and evenly compressed with the proper tools for that purpose, and the finished surface to be free from depressions and truly and evenly surfaced to the finished grades and crown of the walk. The asphalt mastic to consist of natural bituminous limestone rock (1) from the French mines of Seyssel or Mons, equal in quality and composition to that mined by the Compagnie Générale des Asphalte de France; (2) from the Swiss mines at Val de Travers, equally in quality and composition to that mined by the Neuchatel Asphalt Co., Ltd.; or (3) from the Sicilian mines

at Ragusa and the German mines at Limmer, equal in quality and composition to that mined by the United Limmer and Vorwohle Rock Asphalt Co., Ltd., mixed with fine, clean grit and refined bitumen, in such proportions and in such manner as to insure work that shall be sound and free from cracks and impervious to moisture under all climatic changes, and so as not to flow or spread in summer or crack or disintegrate in winter, and as shall be directed by and to the satisfaction of the engineer."

Rock asphalt coulé has been used for many other purposes than in building and for sidewalks. The latest use I have seen was for medallion plaques. Among the larger calls for this material is that for reservoir linings. *Municipal Engineering* in one of its issues describes the construction of one in Astoria, Ore., where the bottom was covered with 6 inches of concrete containing 0.9 cu. yd. of crushed rock, 0.5 cu. yd. of gravel, 0.1 cu. yd. of sand and one barrel of Portland cement per cu. yd. cut in blocks of 20 ft. square, with ½-inch asphalt joints, and this was covered with a ⅜-inch cement mortar finish and two coats of asphalt, one soft and the other harder, and together a little more than one inch thick. The slope had 6 inches concrete, 2-3-inch asphalt, a layer of brick and a second layer of asphalt 0.5 inch thick. The most common practice is probably from 18 to 24 inches of clay puddle under concrete or paving.

One of the large pieces of work in this line was the coating of the Queen Lane Reservoir, Philadelphia, where an area of 235,000 square yards was surfaced in 1896 under the direction of Mr. John C. Trautwine, C. E. In 1897 the reservoir at Coatesville, Pa., with a capacity of 2,000,000 gallons of water, was abandoned on account of excessive leakage, but having been lined with Neuchatel coulé in that year, has been in use and given perfect satisfaction ever since; this work was done under the direction of Mr. Alexander Potter, C. E., of New York, who also had the Phoenixville, Pa., reservoir lined with Seyessel asphalt in the year 1898.

In connection with asphalt coulé a desirable combination of iron with asphalt has lately come into use. This construction has been adopted by the Fire Department of New York for stalls in engine houses; it has been used for the space inside street railroad tracks and one foot on the outside. The pavement consists of cast-iron frames or gratings embedded in asphalt. The frame prevents

the asphalt from creeping and from wearing into holes or grooves. The frame is cast in the form of curved or undulating bars and crossbars, with stubs at the point of intersection. These frames are entirely embedded in asphalt, presenting a plain asphalt surface as in any ordinary pavement. Even under heavy traffic the asphalt wears down only to the stubs. Even when worn the surface shows a minimum of iron and a maximum of asphalt surface. When by such wear the stubs become exposed, the best course is, by the use of surface heater, to lay asphalt about half an inch in thickness upon the surface, which makes the pavement as good as new. At all times the presence of the iron frame prevents the forming of ruts or grooves, even under the influence of summer heat and heavy traffic, and the laying of a new asphalt coating upon worn pavements may be postponed for a considerable period after the iron stubs are exposed, and until a convenient time for making the repairs, the frame in the meantime preventing the destruction of the pavement by wear.

This device is protected by patents. In connection with patents it is interesting to note that the first patent in connection with asphalt was taken out by Admiral, the Earl of Dundonald, in 1851, for the employment of Trinidad asphalt and mineral bitumen of the North American Colonies in the production of artificial stones and other useful objects. He acquired land in La Brea, Island of Trinidad, which still remains in the hands of his family, and the Dundonald property is today contributing material for our city streets.

Other English patents include Pym's composition, patented in 1855, which was composed of 5 cwt. of asphalt, 5 cwt. of chalk or limestone, 1 lb. of sal ammoniac, and as much coarse sand and grit as will mix freely with the above ingredients when heated in a cauldron; the heated mixture is then cast into the desired forms, and if extra toughness is required, cocoanut fiber, shavings, or other fibrous materials must be well incorporated.

In Rowcliff's patent (1855, pt. 2, 906), the asphalt is reduced to small particles, and compressed by hydraulic or other pressure into the desired shapes; sand or powdered stone may, if necessary, be added to it before compression.

Sheil's stone, patented in 1867, consisted of small stone cemented together with asphalt.

R. Skinner's patented asphalt blocks are prepared as follows:

VIEW OF PART OF WEST FRONT AND UPPER TERRACE U. S. CAPITOL, WASHINGTON, D. C.
Being relaid with Neuchatel Rock Asphalt, August, 1898, by The Cranford Paving Company, Washington.
Simpson Bros. Corporation, Boston, Eastern Agents.

800 lbs. of asphalt are placed in an oven and submitted to sufficient heat to drive off water and easily volatized matters. In a short time the material is capable of being easily powdered, and in this state it is introduced into a large revolving cylinder heated up to 200 degrees Fahr., and then are added 300 lbs. each of pulverized slag, coke, and limestone, and about 20 gallons of mineral tar. The tar should be previously boiled to expel water, and thoroughly mixed with limestone before being added to the other ingredients. After mixing and heating, the product is conducted from the revolving cylinder to a revolving pan and the temperature lowered to 150 degrees Fahr.; in this state it is placed in molds and subjected to heavy pressure.

Tucker, an American patentee, also compressed mixtures of slag and asphalt into blocks.

Fottrel's patent in 1873, pat. 3,086, prepares an artificial stone especially adapted for making drains, pipes, etc., by boiling together a mixture of 13 cwt. of finely powdered stone, 4 gallons of shale oil, 2 cwt. Trinidad asphalt, and 2 cwt. bituminous rock. When thoroughly mixed, the composition is run into suitable molds.

M. Leon Malo patented in France in 1873 his asphalt comprimé blocks which have so long been in use in that country and which recently have been in great demand in Cairo, Egypt.

Wilkinson's patent Trinidad asphalt blocks, generally known as the "Hasting" blocks, seem up to the present to have had the monopoly of such construction in this country and South America.

For quite a number of years these blocks were made of limestone, but in 1893 trap-rock was substituted for the limestone. Blocks made of this latter material give much better satisfaction on account of the greater durability of the trap-rock, and at the present time that material is being used entirely in the manufacture of the blocks. Asphaltic cement is mixed with the trap-rock in proper proportions at a temperature of about 300 degrees. The material is placed in a press at this temperature and each block is subjected to a pressure of 120 tons. After leaving the press the blocks are gradually cooled in a water bath, and are then ready for use.

In the earlier years of the industry blocks were made 4 × 5 × 12 inches. A depth of 5 inches, however, was considered to be unnecessary, and the present practice makes them of the same dimen-

sions as above, except that the depth is 4 and 3 inches, the blocks weighing 13½ and 18 lbs., respectively. These blocks are carried to the streets and laid upon a base of either gravel, broken stone, or concrete, as the case may be. The blocks are laid in practically the same manner as are bricks, the joints being filled with fine sand.

Another form of asphalt blocks, known as the "Jenner" patent, is sometimes used, in which the broken stone is replaced by granulated cork. Such blocks were laid on Fifth Avenue, New York, between Thirty-fourth and Thirty-sixth streets, in strips ten feet wide, adjacent to the curb. The grade on these two blocks being somewhat steeper than the remainder of the avenue, it was deemed best to provide a better foothold for horses in slippery weather than the ordinary asphalt. The blocks are $2 \times 4\frac{1}{2} \times 9$ inches, and were set flatwise.

The courtyard of the Waldorf-Astoria was afterward laid with such blocks. This pavement was laid in the fall of 1897, and in the spring of 1900 was in very good condition. It cost $5.25 per square yard, exclusive of foundation, under a fifteen-year guarantee. Although very desirable for driveways and bridges, cork blocks can never be very generally used on account of their excessive cost.

The question of patents has taken me from the subject of asphalts mastics to which I must return. For sidewalks or iron bridges asphalt coulé is often used where the roadway is of asphalt pitch composition, or, as is known, the "Standard American Pavement," as being subject only to footwear on the top surface—need only be laid one inch thick, and here, as in other cases, where heavy steam rollers cannot well be used for compression, the mastic is preferable, as it is so solid when poured on the surface to be covered that it needs only a slight pressure from the workman spreading it to the required grade.

The American rock asphalts have not proved satisfactory for the manufacture of mastic; this is from the fact that they are generally of sand-rock and not lime-rock formation. A company in St. Louis tried the experiment of making a mastic from the Indian Territory asphalt sandstones, but I understand abandoned its use for that of European rock mastic. Another Western firm tried the use of Kentucky asphalt sandstone, but also changed to limestone. The single exception, I personally know of, is found in

the Texas rock asphalt mixed near Cline, in Uvalde Co., which is a genuine asphalt limestone. I visited these mines in the spring of 1901 and was much interested in the formation, which was shell limestone richly impregnated with bitumen, the average analysis showing 16 per cent. of bitumen with streaks much richer. I obtained very fine specimens of fossils showing different kinds of shells and proving that the mine had originally been under the ocean. This rock having been reduced to a powder is rich enough to be cooked into a mastic without the addition of bitumen, a small percentage of maltha, however, is desirable to cause it to flow readily into molds. At San Antonio a large stable in the rear of the "Menger" Hotel has a floor laid some years ago with this material which has stood the test of hard usage even better than the average European mastic. It has been laid also in Houston, Texas, to a considerable extent, but the heavy cost of freight prohibits its use in the East; New Orleans, however, may prove a favorable point for its use.

Chapter III.

TRINIDAD ASPHALT.

TRINIDAD asphalt is the bitumen best known in the United States, and its use for street pavement has been colossal. This asphalt was first used as a substitute and improvement on coal tar for roofing and like purposes, and succeeded the coal tar pavements first brought into prominence in the "Tweed Ring" days.

In 1870 Professor E. J. De Smedt, a Belgian chemist, laid what is believed to have been the first sheet asphalt pavement in this country in front of the City Hall in Newark, N. J. His European knowledge led him to endeavor to make an artificial bituminous mixture on the line, as far as possible, of the natural rock asphalt powder used in Paris.

In 1873, Fifth Avenue, New York, opposite the Worth Monument, was laid with this composition which was described as a mixture of properly selected sand and pulverized carbonate of lime cemented together by suitable asphalt, the latter being first refined and tempered with heavy petroleum oils or residuum.

From these beginnings have evolved the immense industry of the "Standard Asphalt Pavement," of which to-day, there are forty million square yards in the United States, and of this quantity it is claimed 85 per cent. is of a mixture in which Trinidad asphalt is used.

Municipalities and engineers have been greatly exercised over the question of the supposed difference in asphalt refined from the Pitch Lake and from adjoining properties. The writer has always maintained that there was no difference in the qualities and this is now the generally accepted decision of army engineer officers and city engineers.

The deposit of the Pitch Lake, as described by Mr. P. W. Henry, general manager of the Barber Asphalt Paving Co., occupies a bowl-like depression, probably the center of an extinct mud volcano, some of which are found in other parts of the island.

TRINIDAD ASPHALT LAKE, NEAR THE EDGE.

The center of the deposit is about three-quarters of a mile from the shores of the Gulf of Paria, and about 135 feet above the level of the sea, making it easier of access and simplifying the question of shipment. The surface is hard enough, except in irregular patches in the center, to bear the weight of carts and mules. It is necessary, however, for one to keep moving, otherwise he soon sinks in the material which, under the hot rays of the sun becomes quite mobile, although not sticky, owing to the large amount of water which it contains. The surface of the deposit is divided into irregular areas, from 60 to 150 feet in diameter, separated by crevices several feet across and from six inches to six feet or more in depth, in which rain water collects and in which fishes, some six inches long, resembling mullets, disport themselves. Each of these areas has a motion of its own from the center to the edge, due to the gas which is being evolved. If a stake is placed in the center of one of these areas it will gradually work to the edge and finally disappear. The crevices are found where the different areas meet, and although the edges of the asphalt in these areas touch each other at a greater or less depth, they do not appear to unite.

This deposit has well been called a lake, and it possesses the qualifications which such a name would imply. It occupies limits well defined by shores. From borings made it appears that the deposit occupies a bowl-shaped basin, the bottom of which 100 feet from the shore is about 90 feet from the surface. The depth in the center is unknown as it was impossible with the implements employed to bore to a depth greater than 135 feet, through all of which the material was similar to that on the surface.

When asphalt is dug from any portion of the deposit, in the course of a few days the hole is filled by new material coming from below, but the entire area of the lake, 114 acres, is lowered in consequence, showing that the mass acts as a liquid of less mobility, however, than water.

The composition of the asphalt is of remarkable uniformity, no matter from which portion of the lake it is taken. Samples taken 135 feet deep at the center did not differ in composition from those taken on the surface a few feet from the shore, showing the homogeneousness of the entire mass. Then, too, the surface is in constant motion. There are on the surface of the lake half a dozen or more islands, from 50 to 150 feet in diameter, composed of floating vegetation, with trees thirty to forty feet high

and dense undergrowth. From accurate surveys it was found that one of these islands in one year moved over 25 feet. There are also more rapid movements corresponding to currents and eddies in a lake. In making surveys for the tramway, different lines were run across the lake and stakes put in every 100 feet. These stakes were put in line with a transit, and the following day the alignment was about the worst possible. In 20 days one of the stakes had moved 24 feet, or over a foot per day, and other stakes from that amount down to a few feet.

This motion is due to the evolution of gas which is constantly being given off, and in some places in such quantities that it can be ignited by a match. Then, too, the lake is fed by springs bringing in new material to the amount of at least 10,000 tons per year. Near the center of the lake this soft asphalt appears and spreads over the old and hardened surface. The lighter oils evaporate under the rays of the tropical sun and the new material then becomes hardened like the rest of the lake.

The resemblance of this deposit to a lake may therefore be summed up as follows: Its occurrence in a basin with well defined shores and bottom; its movement as a mass, preserving its level; the uniformity of its composition; the movement of its surface; the presence of islands and the existence of springs.

From levels taken by Mr. Henry in February, 1893, and again a year later, it appears that the center of the lake is almost a foot higher than the edges. This is probably due to the ebullition of the soft asphalt near the center. Levels have been taken every year since that date, and it appears that the lake preserves its contour, although the general level has been lowered nearly four feet in the past eight years. It has been found that the removal of about 18,000 tons of asphalt will lower the level one inch, and as the output is about 100,000 tons per year, the level is lowered from five to six inches per year.

From the borings, however, it is evident that for several generations to come there will be no shortage. These borings were made with the ordinary portable water-jet machine, such as is used in making borings through sandy material, and it was well suited for the purpose. It took several days to make the borings in the center of the lake, and by that time the casing had gotten so far out of plumb, due to the motion of the asphalt, that it was impossible to drive it any deeper. This casing finally disappeared,

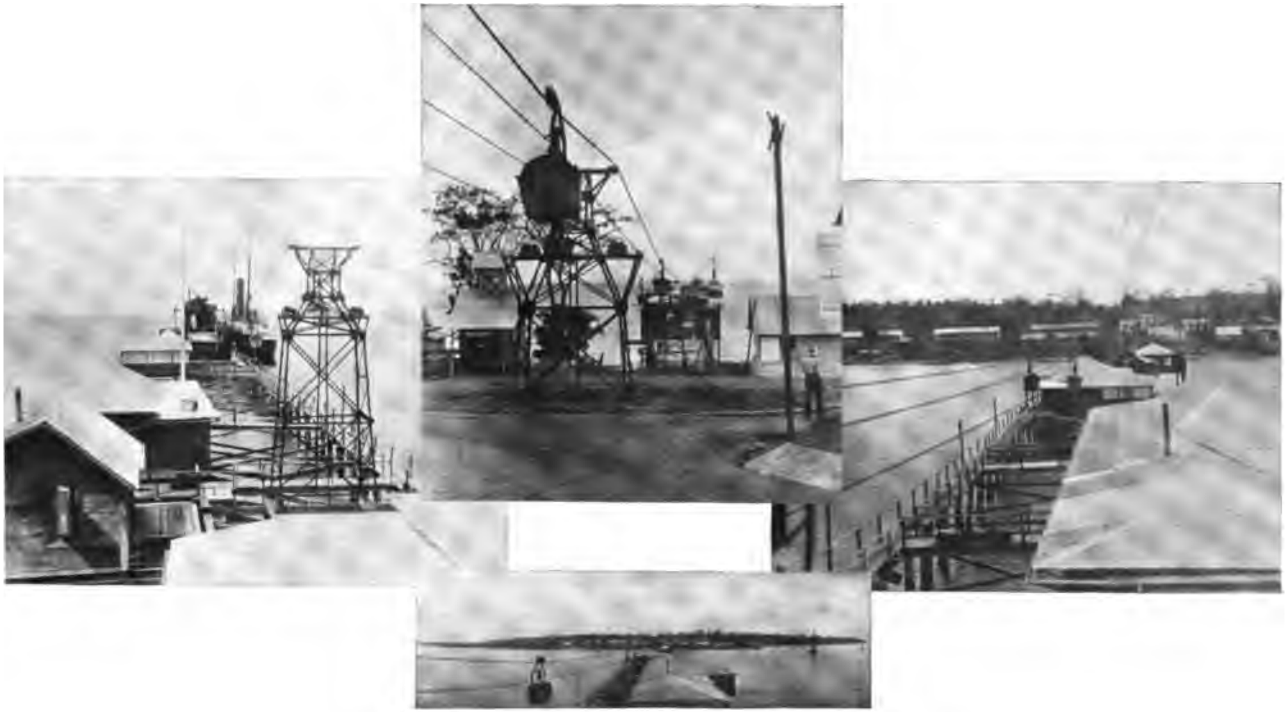
although its top originally stood six or eight feet above the surface.

The asphalt is dug by means of picks or mattocks just before dawn, when the asphalt is comparatively brittle, and in the early days of the industry was loaded upon carts and taken to the beach, where it was stored until the arrival of vessels, or dumped directly into lighters which carried it to the sailing vessels or steamers anchored half a mile out from shore.

As the business increased it became necessary to install more rapid and economical methods of loading. Surveys for the tramway and pier were made in February, 1893, by Mr. Henry, who outlined the plan finally adopted. Detailed plans and specifications were made by L. L. Buck, C. E., and the resident engineer in charge of erection was E. G. Freeman, C. E., and it was finished in the fall of 1894.

In consequence of disputes and claims of inferiority of the so-called "Land Asphalt," Professor S. F. Peckham, in 1895, visited Trinidad, and as the result of his investigations reported that he was "quite at a loss to determine why Mr. Richardson alleges such a specific distinction between what he is pleased to term 'lake' and 'land' asphalt. It appears to me to be a distinction without a difference."

Professor Peckham states that it is evident that for an indefinite period there has been an outflow of bitument from the lake towards the sea, at La Brea, not over its rim, but through a crevice in its side; in fact, through its broken-down side; and that, notwithstanding the vast quantities of asphalt now being taken from the lake by the concessionaires, the movement is still out of the lake. Captain Alexander, in 1832, spoke of the flow out of the lake as "immense." Manross, in 1855, says: "This stream of pitch has been dug through in several places, averaging from 15 to 18 feet in depth. A well dug at one point on the slope of the overflow, was abandoned still showing asphalt, at the depth of forty feet. Several village lots have ben excavated to a depth of twenty feet still in asphalt. The invariable reply of the negroes to the question: "Have you ever dug through the asphalt?" was, "No, sir." The conclusion that Professor Peckham reached on the ground was, that the asphalt flowing down the slope to the sea fills a ravine excavated by water, and that it is slowly moving out of the lake with the pressure of the asphalt in the lake behind it.

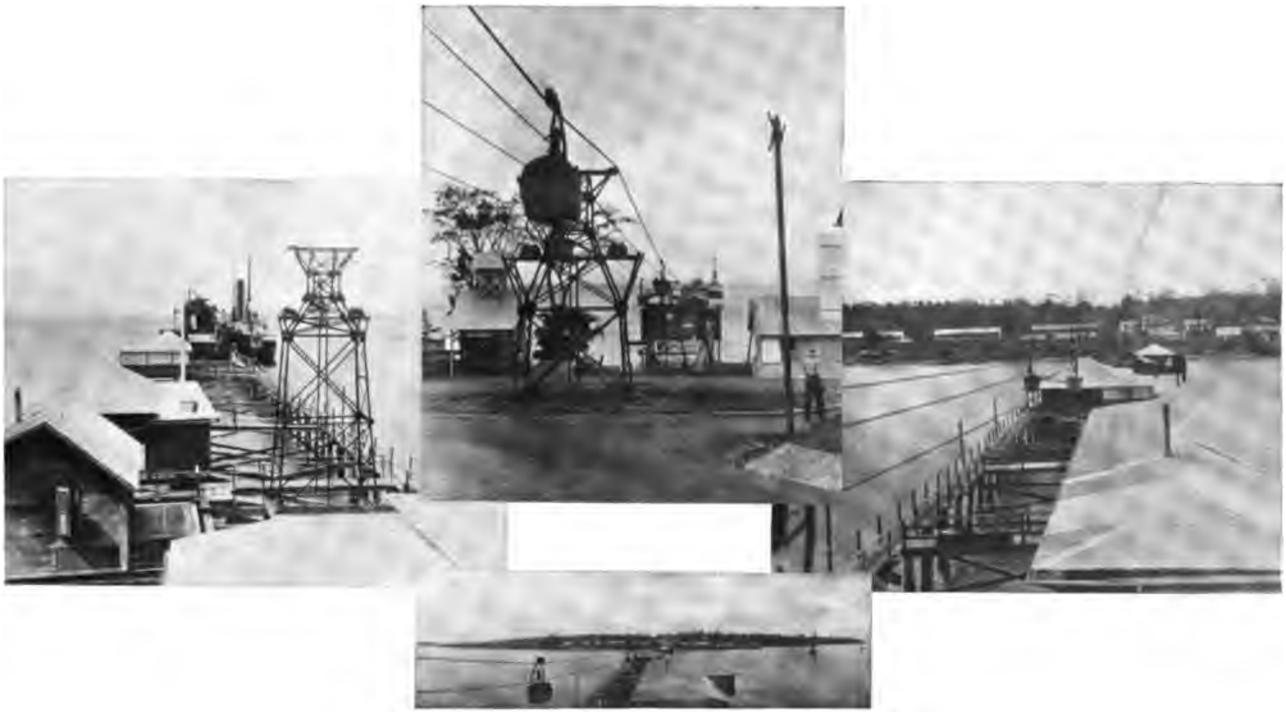


METHOD BY WHICH ASPHALT IS TRANSPORTED FROM THE TRINIDAD ASPHALT LAKE TO SHIP.

This conclusion is in harmony with the testimony of observers for the last hundred years. It is from one of such overflow deposits in the village of La Brea that the asphalt from the Countess Dundonald's property is obtained. The Roman Catholic Church property also has reduced large quantities of asphalt which has allowed of the competition in asphalt pavement work, which was so prominent a feature during 1899 to 1902.

For paving purposes refined Trinidad asphalt of itself is too hard and brittle to form the cementing agent to bind the particles of sand together. It is therefore necessary to use a flux to bring the asphalt to the proper consistency. For this purpose petroleum residuum has been generally used, although liquid asphalts from California have been used to some extent and with more satisfaction.

As liquid asphalt is more expensive and residuum has been used for many years with fair results, it has been the fluxing agent in general use. Professor Samuel P. Stadler, after exhaustive tests gave the opinion that oil residuum should not be used, and that maltha, of the nature of the California liquid asphalt, was the best flux.



METHOD BY WHICH ASPHALT IS TRANSPORTED FROM THE TRINIDAD ASPHALT LAKE TO SHIP.

Chapter IV.

PETROLEUM RESIDUUM AND CALIFORNIA MALTHAS AS A FLUXING MATERIAL.

REFERRING to the use of petroleum residuum as a fluxing material, this residuum is a heavy, dark oil, resembling the cheaper lubricating oils, and contains none of the lighter oils. Its gravity is from 20 degrees to 22 degrees Beaume, flash point about 450 degrees F., quick flow at 78 degrees F., and containing only a few per cent. of volatile matter in seven hours at 400 degrees F.

In order to make a satisfactory asphalt cement (as the mixture of refined asphalt and residuum is called), it is customary to mix it in the proportion of about 100 parts of refined asphalt to 20 parts of residuum. The asphalt is first melted in tanks and the residuum is then added and thoroughly mixed by agitating with air or steam. As the quality of the residuum varies, it is not possible to gauge the exact amount necessary by weight. Samples are therefore taken by the foreman in charge and tested by chewing. By practice a man can become expert in this line, but it is of course necessary to have a standard sample for comparison. At the laboratory and at the larger plants the consistency of the asphalt cement is tested by an apparatus called the penetration machine, and the consistency of the cement is recorded. Other methods for determining the consistency are also in use, and each has its merits. For quick service the chewing test is as accurate as any other, but there is no method of recording its results. The asphalt cement, which in the tanks is carried at a temperature of 300 degrees to 350 degrees F., is now ready for use, and is added to the hot sand and other mineral matter in a mixer which is simply a box encasing two shafts revolving in opposite directions, on which are blades shaped like propeller blades. The mixture is generally made in batches of nine cubic feet, and the time of mixing is from a minute to a minute and a half. The resultant mixture is

then dumped into wagans, hauled to the street, raked and rolled with a steam roller, and the asphalt pavement after a few hours cooling, is then ready for traffic.

In 1894 the Citizens Municipal Association and Trades League of Philadelphia employed Professor Samuel P. Stadler and Mr. J. Edward Whitfield to investigate the properties of the different fluxing materials and they reported that "better, stronger and in all probability more durable paving composition can be made than those now being made with the aid of oil residuum." This decision was based on exhaustive tests of Trinidad with California and Utah Malthas.

The general deduction was that the blending of the asphalt and the oil-residuum is an unsatisfactory one on the score of its lack of durability, and I have since found from conversation with practical men of many years' experience in asphalt paving that such is the common belief. It is also admitted by the chief writers on the subject of asphalt paving that the quality of an asphalt is reduced in the ratio of the percentage of increase of petroleum oil used.

There are two methods as stated by Messrs. Stadler and Whitfield by which the use of petroleum residuum in asphalt paving mixtures can be done away with; the first is to find natural asphalts which retain sufficient of their original asphaltic oils to make it possible to use them with no other admixture than the proper amounts of sand and pulverized limestone, the other is to mix with the hard natural asphalts, liquid natural asphalts, of which a number are found on the Pacific Coast, and in Utah, Idaho, Montana and elsewhere in the West.

The second method of making a paving composition which shall do away with the necessity for the use of the oil residuum is to flux the solid asphalt with the natural liquid asphalt. This has been done already in California with excellent results.

As no figures had then been published by which one could judge of the reliability of these claims, it was determined to make a study of the paving compositions that could be made with the liquid asphalts used as tempering material for the solid asphalts. They therefore procured a quantity of California liquid asphalt and a specimen of liquid asphalt from Utah. In order to have a clear understanding of the nature of these materials and how their addition would effect the composition of the finished mixture, it was

thought desirable to make a partial chemical analysis of them, determining the amount of bitumen contained and its quality.

These analyses showed: California maltha 98.70 per cent. of bitumen, and in the Utah 76.15 per cent. of bitumen, both soluble in carbon disulphide.

California asphalts in forms of Maltha Brea, and Stone or Rock asphalt are found in abundance in the Southern and Southern Central counties of the State. They were known to and used by the native Indians for making their canoes watertight, and in some measure as a mortar for cementing together the stones of their rude buildings, unconsciously following the practice of the Babylonians more than 4,000 years ago.

As Maltha, the bitumen oozes from orifices in the earth, called locally "Tar Springs."

At Brea, this exuded Maltha lies in blanket form, usually in thin masses but sometimes in deep bodies filling up holes, chasms and ravines. Under the action of the sun's heat the soft Maltha has slowly thrown off its volatile elements, which with the action of the oxygen of the atmosphere has produced a more or less hard and brittle asphalt, more or less pure or mixed with earthy matter.

As Stone or Rock asphalt it is found in many places in regular, true fissure vein formation of very old geological age, the volatiles nearly eliminated from gases and from the rocks and earth surrounding and covering it.

The Maltha, as issuing from the Tar Springs is usually very pure in bitumen.

The Brea is less pure and very variable, according as it gathered much or little sand, gravel or soil in its progress of crawling under the sun's heat.

The Rock Asphalts are also widely variable in bituminous purity, according to the amount of earthy or fossil matter intruding into the bitumen while still viscous or even at its earlier stage of fluidity on its way up and through the earth fissures.

In one or other of these forms these asphalts have been in use in increasing quantities since the advent of Americans in California, most largely for roofing, next for paving and for lining reservoirs and tanks, and to a large extent for coating water pipe and protecting it from rust, acid and alkalies.

For paving, the Rock Asphalt has been quite largely used in the Pacific Ocean States and Territories, but paving material made

from Refined Maltha is now being more largely employed owing to the very high purity of the bitumen, enabling shipment to far distant points with virtually no dead matter in its composition to pay freight and handling on. The following table, giving an analysis of a common type of these Refined Malthas, will illustrate this:

TABLE III.

REFINED MALTHA PAVING CEMENT.

Water and volatiles Loss at 212° Fahrenheit:	.09%
Total bitumen	98.33%
Ash (finely divided silicium)	1.58%
	100.00%
Bitumen composed of petrolene	75.15%
Bitumen composed of asphaltene	24.85%

Specific gravity of the cement, 1,050.

Considerable quantities have been shipped to states east of the Rocky Mountains, and the increase in demand has shown a rapid growth from year to year. Shipments via Panama and Cape Horn to Europe are increasing, and an active trade is beginning with Asiatic Pacific countries. A recent shipment of some 500 tons on account of a 5,000 ton order has been made to Australia.

Several thousand tons are used annually for coating wharf piles which the asphalt effectually protects against Teredos and Limnoriae.

Some ten years ago a civil engineer (Mr. Templer Tickell) in employ of the British Government at Singapore shipped a quantity of refined asphalt from California and applied it upon the timbers of bridges, docks and buildings to test its efficacy in resisting the depredations of the wood-eating ants, which range in great armies through the Straits Settlement and attack everything of wood, completely consuming heavy timbers. The asphalt resisted them perfectly.

Applied to metal surfaces which in the very hot and very humid climate of Polynesia corrode to an extent unknown in cooler and drier climates, Mr. Tickell found the California asphalts a perfect protection. The use of California asphalts for street pavements in eastern cities is growing rapidly.

Samples of them were recently submitted to Professor A. W. Dow by a Western Asphalt Company and resulted in the following analysis and report:

LIQUID ASPHALT REFINERY AT BAKERSFIELD, CAL.
Under management of T. Hugh Boorman in May, 1905. John S. Lamson & Bro., New York, Sales Agents.

Table IV.

ANALYSIS OF CALIFORNIA ASPHALT.

	(D) Hard. Bitumen.	(G) Maltha.
Total bitumen soluble in carbon disulphide	99.10%	99.68%
Organic matter not bitumen	0.54%	0.12%
Silica and clay	0.36%	0.20%
	100.00%	100.00%

"None of the samples were appreciably altered by being kept at 300 degrees for six hours in an open vessel. This paving cement is of the right consistency to make a good paving. It is adhesive and elastic. It is not brittle at a low temperature, nor does it become too soft at a high atmospheric temperature. These samples are superior to any I have ever examined in physical properties, and rank among the better asphalts for paving purposes. Your (D) Asphalt Paving Cement, by combining with your (G) Liquid Asphalt will produce a most splendid article."

Chapter V.

VENEZUELA ASPHALT.

VENEZUELA asphalt is more widely known to the public through the serious law suits which have almost caused international complications than from its actual business productions, and I might almost say that Venezuela is about as prolific in law cases as in bitumens, but there are certainly large deposits of the latter throughout the republic.

The Bermudez Lake, which up to the present has really been the only important source of supply, is situated across the Gulf of Paria, about 105 miles due west of the Trinidad Pitch Lake, in the State of Bermudez, Venezuela. It lies in a straight line about 20 miles from the gulf, but by the San Juan and Guanoco Rivers the distance from the bar at the mouth of the river is some 40 miles.

The San Juan is a deep, wide river and although there are only 19 to 20 feet of water at the bar, in the river itself, the water is in many places over 100 feet deep. From the San Juan branches a smaller river, the Guanoco, and three miles from the junction is located the wharf along which steamers drawing 18 feet of water can lie and receive the asphalt. This wharf is located about five miles from the asphalt lake, to which it is joined by a narrow-gauge steam railroad. The lake covers an area of about 1,000 acres, being nine times the area of the Trinidad lake.

This larger area does not necessarily indicate a larger amount of material in the deposit, for the asphalt in many places is only 2 to 10 feet deep. There are many springs of soft asphalt or maltha, the largest being about seven acres in area. Outside of the springs where new material is constantly exuding, the surface of the lake is covered with vegetation and trees, which must first be cut off to reach the asphalt.

The quality of the asphalt varies from the maltha, or liquid asphalt, exuding from the springs to the hard glance pitch which has been produced by fires which during the dry season sometimes

sweep across the lake. Underneath the roots of vegetation is the asphalt of commerce, which is handled in much the same way as Trinidad, although it is considerably softer.

Its composition also differs considerably from that of Trinidad, and the crude material does not present the uniformity of Trinidad. The crude Bermudez asphalt contains water, but it is present as a mixture and not as an emulsion. In percentage the water varies from 10 to 4 per cent., averaging 31 per cent., whereas in Trinidad asphalt the quantity is constant at 28 per cent. The mineral matter also varies from less than 1 per cent. to more than 3 per cent., while the organic matter, not bitumen, varies from 1 to 6 per cent.

An average analysis of the crude material from the lake is as follows:

Bitumen	66 per cent.
Water	31 per cent.
Mineral matter	1 per cent.
Organic matter, not bitumen	2 per cent.

In this case, as with Trinidad asphalt, the only element to be eliminated is water, and this is done in the same manner.

The asphalt, although considerably softer than Trinidad, is dug in a similar manner and loaded into small side-dump cars running on a portable track. These cars are pushed by hand to the terminal station on the shore of the lake, where they are dumped into boxes contained on flat cars. These cars are then taken by the locomotive to the wharf on the Guanoco River, about five miles distant, and dumped directly into the vessel, if one is alongside, otherwise they are dumped on the shore of the river, where there is considerable storage place.

As the material is softer than Trinidad asphalt it is necessary to have the hold of the steamer or sailing vessel divided into compartments in order that the material may not move too freely. If this were not done, the sailing vessel would get such a list in sailing for any length on one tack that it would be impossible to get her on the other tack, and the vessel would finally capsize. This same difficulty to a less extent would also occur in steamers where no provision for bulkheads was made. There is now at the Bermudez lake a refining plant.

The first pavement laid with this material was on Woodward Avenue, Detroit, in 1892. Since then, it has come into general use

in different cities of the country. When refined, the asphalt contains of bitumen 97.22 per cent.; mineral matter, 1.50, and organic matter, 1.28. The bitumen is composed of petrolene 77.90 and asphaltene 22.10 per cent. The specific gravity is 1.08. The Bermudez asphalt has also found great favor from civil engineers, and large quantities have been used in reservoirs and other large construction work; the largest contract calling for its use is in the Rapid Transit Tunnel in New York, where all walls in contact with the earth were waterproofed with felt and the Venezuela bitumen. From Perdenales some shipments have been made and at Maracaibo a large refinery has just been erected.

It has been thought by some scientists that all the Trinidad and Venezuela asphalts have a common origin in volcanic eruptions in the Gulf of Paria.

Since the publication of the article on Trinidad asphalt there has been received a copy of a most interesting report on the Pitch Lake and its surroundings submitted to the Governor of Trinidad by acting Surveyor-General, Edmonstone Hodgkinson, under date of January 14, 1824. After three-quarters of a century the statements of his impressions have been verified, and his views are an interesting addendum to the literature on the subject.

He stated that the Lake is situated upon the top of a ridge, about 25 or 30 feet above the level of the sea, from which there is a fall at three sides, on the North and West towards the sea, and on the East towards the interior of the country. It is principally towards the North that the Lake empties itself into the sea (if the expression may be used of that which has no sensible motion), but the formation of the stream, of pitch from the lake to the sea, a distance of about a mile and a half, is too apparent from the fact, to be mistaken.

The pitch which the lake presents to the view is by no means the whole the district furnishes, the lake is merely the part over which the soil has not spread, so as to permit the growth of grass and wood on it, but there is a vast quantity of pitch from it, detached in portions, particularly to the northward up to and upon the seashore, and to the westward upon the estate of the late Madame Boussac, now held by Messrs. Montrichard, Labastide and Saubot.

The different qualities of pitch observed are three in number, of which two may be said to be inexhaustible, the deficiency of any

CENTRAL PARK WEST.
Laid with California Asphalt.

that is taken away being quickly supplied by reproduction. These are the pitch of the lake and the liquid pitch found on the lot of M. Saubot, on both of which the volcanoes and the matter rising to the surface from them are distinctly visible. The liquid pitch found is in detached spots, sometimes near to and sometimes at some hundreds of yards distant from each other upon the land of M. Saubot, and the land called Ozon's, now also belonging to M. Saubot. These spots which are said to be about twenty, and of which ten or twelve were visited, are circular, of about 30 feet in diameter, with the volcano in the center from which a bubble like that of boiling water rises and bursts about every minute. The pitch is so nearly liquid that the specimen brought up was raised with a stick and let to run from it into a narrow-mouthed jar at 8 o'clock in the morning with the thermometer at 79 degrees.

The nearer to the volcano that the pitch is taken the more liquid it is, being then about the consistence of tar when prepared for use on board ship, but this liquidity ceases on its removal, although it is restored by exposure to the sun in this climate. The third sort of pitch differs in the external appearance from both the foregoing; it is neither liquid like that last spoken of, nor in a mass like that of the lake, but it is found under the surface and in the immediate vicinity of the liquid volcanoes in dumps or blocks about the usual size of pieces of sea-coal taken out with the soil, so loose that they may be taken out with a cutlass or any instrument sufficiently strong to remove the earth. This pitch, when the earth is washed off, appears blacker than that of the end of the lake. It may be that it was visible, for the spots which contain earth are not found in contact. On the contrary the liquid pitch abounds upon the land of Saubot, nearer the lake, and the latter is mostly found further off and upon the land called Ozon's.

If the pitch in blocks exists to any considerable depth—which there is no reason to disbelieve, but which fact is known—there will be found sufficient for almost any purpose, but it cannot be called inexhaustible with the confidence applicable to the other kinds, because its reproduction is not visible.

Common experiments for fathoming the volcanoes have been tried in vain—large sticks 60 feet long have been swallowed perpendicularly in the course of a few hours. A line would not answer the purpose, because it could not be redrawn. Mules and oxen have been frequently lost on them.

Reverting to the lake and to the assertion that it empties itself into the sea, it may be observed that the whole natural savannah of La Brea, abou a mile and a half in length and about a quarter of a mile in width, is entirely pitch over which, except that part which is kept clear for the road, the soil has contrived to spread a thin covering of itself upon which the fox-tail and other coarse grasses grow. And this savannah is evidently the stream by which the pitch of the lake is emptied into the sea, however long the time may be that its passage occupies; but that there is a motion is certain, both by the houses in the village of La Brea on the seashore, which are sometimes raised a foot or two more at one end than the other, continue so for a year then the road which is annually made from the lake to the village by cutting out the watercourses with hatchets, is again filled with pitch before the return of the period.

A fourth sample of pitch has been brought up, being that found at the village on the seashore. The intention of this is that it may be ascertained whether the pitch has deteriorated in quality in its passage from the lake to the sea, as if it has not, it may be cut out on the seashore at the very prow of the boat that would take it and the carriage from the lake would be saved.

There is a bar off Point La Brea, but the anchorage for shipping is good inside. Off the shore the pitch under the sand has made the water shallower than it would otherwise be.

CHAPTER VI.

CUBAN ASPHALT.

THE Cuban asphalt industry has not yet been fully developed, but recently has been brought prominently to notice in consequence of a report prepared for the U. S. Government by Mr. T. Wayland Vaughan at request of General Leonard Wood. It will be readily understood that during the Cuban revolution nothing was done in the way of working deposits, but prior to that period, some fifteen years ago, attempts had been made to utilize the Cuban asphalt for street pavements; there was a project to mix the asphalt with clay and other ingredients, but no successful results were obtained, and work attempted at Washington proved a failure.

At the World's Fair in Chicago some may remember the solid block of asphaltum weighing 1,024 pounds, which was exhibited by Mr. Otto D. Droop, and which was analyzed by M. Leon Malo as

Pure bitumen	70.00 per cent.
Foreign matter	24.50 per cent.
Water	5.50 per cent.
	100.00 per cent.

This came from the asphalt mine known as "Angela Elmira," which is located about five miles from the town Bejucal in the Province of Habana, and which was then owned by the West Indies Co.

The present owners made their first shipment to the United States in January, 1901, and brought their material before the District of Columbia authorities in a practical way by demonstrating that a good paving mixture could be obtained by the blending of the material with a pure California liquid asphalt.

Professor Dow in his last official report said of the sample of crude asphalt from the "Angela Elmira" mine and a sample of California maltha: "A proper combination of this asphalt and flux produce a cement that from all indications will rank among the best for paving," and portions of two streets in Washington were

last year laid with this mixture. This material, which is a hard asphalt, is of course applicable to many purposes other than that of paving.

Mr. Vaughan in his report says that the occurrence of mineral pitch or asphalt in the Island of Cuba has been known since the time of the Conquest. In the "General History of the Antilles," by Oviedo, published in 1535, mention is made of a spring of pitch near the coast in the Province of Puerto Principe.

This material was used with an admixture of grease for painting the hulls of vessels. The same author mentions the occurrence of pitch upon the shores of Habana Bay, where it was also used for a similar purpose. The presence of this mineral was noted by Humboldt, who visited the islands in 1803, and it was mentioned both in the personal narrative of his voyage and in his essay upon the Island of Cuba. It is probable that Humboldt visited some of the localities which have since become prominent as asphalt mines in the vicinity of Habana. He reports that it occurs in the serpentine rocks in the form of fissure veins. He observed also some fluid bituminous material of the nature of petroleum running out of fissures in the same rock.

In 1828 La Sagra, published in "Anales de Ciencias, Agricultra, Comercio y Artes," a journal formerly printed in Habana, a somewhat extended account of the occurrence of asphalt in the vicinity of Habana. Reference has also been found to a memoir on the bituminous deposits by one Navarro, published in 1829, and another by Moisant, in 1857, entitled "Memoria sobre los Productos Bitumenosos de la Isla de Cuba." There is no question that asphalt is to be found in every Province in Cuba, but its commercial worth, as stated by Mr. Vaughan, should be carefully considered before large investments for developing are made by capitalists.

Cuban maltha has been imported in some quantities for fluxing purposes. Of this quality of bitumen, Mr. J. L. Hance, in a consular report, says near what was formerly the town of Sabanillo de la Palma, about 30 miles east of Cardenas and some four miles west of Hato Nuevo, on the north side of the railroad, is the well of J. B. Hamel. This well is sunk to a depth of about 80 feet in serpentine rock, and into it oozes a thick mineral tar.

The material is drawn out by hand power, bucket and windlass being used. The output is about 20 barrels per day. In the vicin-

PENNSYLVANIA AVENUE, WASHINGTON, D. C.
Laid with Bermudez Lake Asphalt, 1907.

ity of this well are two others, one about 300 feet further east and the other about 600 feet to the west. The mode of occurrence of the mineral is the same. No area of limestone was discovered associated with the asphalt, but fragments were struck in the well.

About a mile southwest of Mina Hamel and about 300 feet north of the railroad is another area of natural tar wells or springs; one well is said to be 60 feet deep. Maltha has exuded from it over a considerable portion of the immediately surrounding surface. The area of mineral tar occurs within a shallow topographic basin. There are hills occurring on both the north and south sides rising to 75 or 100 feet above the included depression.

The elevation at Mina Hamel is probably not more than 25 or 30 feet. One hole in this vicinity, according to H. E. Peckham, was fired during the last insurrection and burned for four months until a heavy rain finally put it out. At present the ground for 70 or 80 feet around this hole is covered with coke. The well itself is full of rain water upon which float masses of vegetation stuck together with bitumen that comes from below. A pole pushed down into the water 8 or 9 feet meets resistance in a soft, yielding material, and if this can be brought to the surface it will be seen to be the same as that in the neighborhood.

In Mr. Hance's account of the submarine deposits of asphalt from the Bay of Cardenas he says: "The deposits in the bay from which asphalt has been taken are four in number and of two grades. No. 1 is in the western part of the bay and produces a very fine grade of practically pure asphalt, used in the United States for the manufacture of varnish.

I have myself seen a serviceable varnish made by the simple process of dissolving this quality of asphalt in turpentine. Asphalt has been taken from this deposit in large quantities for the last 21 years. Recently, however, the work has not made rapid progress, owing to the frequent caving in of the sides of the shaft.

The mode of operation is almost primitive. A lighter is moored over the shaft, which is from 80 to 125 feet in depth—varying according to the rapidity with which the asphalt is removed and replenished. A long iron bar with a pointed end is raised by a winch on board the lighter and allowed to fall, so that its own weight detaches portions of the asphalt, which is about as friable as cannel coal, and has much of its appearance. The gloss, however, is more brilliant. After a sufficient quantity has been de-

tached, a common scoop-net is sent down and filled by a diver—not in a diving suit."

Mr. William Palmer, of the United States National Museum, says that of the asphalts in the Province of Pinar del Rio, the mines entitled Rodas Concepcion and Magdalena, belonging to Don Ramon Balsinde, as well as the sugar plantations, Canas and Tomasita, on which these are located, are at the head of the extensive Bay of Mariel. These are mines worked under the open sky, upon masses of asphalt, notable for their dimensions, especially the mine Magdalena in plantation Tomasita, which measures in the part already laid bare by the works, 12 meters of thickness and more than 100 in length. This mass lies in the direction of west-southwest to east-northeast, and is probably a continuation of the other two mines situated on the neighboring plantation of Canas.

Mr. Wm. Palmer says that on the rough exposed surface of the reef at Mariel there are patches of asphaltum from 1 inch to 6 or 8 inches in diameter and rarely more than ½ inch thick. They occur always in the higher portion of the rock between cavities, and appear to have been drawn out by the heat of the sun.

One mile south of Mariel Bay is a deposit of asphaltum which has been quarried to a depth of about 50 feet. Several wagon loads were taken to the barracks at Guanajay. It is barely possible that this locality corresponds to one of the two mines above described. Mr. Palmer states that there are other occurrences of asphalt eight or ten miles to the southwest.

Near the town of Banes, between Mariel and Habana, are two other mines, known as San José and Constancia, which are the property of Mr. Henry L. Cranford. These mines have never been worked extensively, and, according to Salterain, the production scarcely reached 400 tons during the two years preceding 1883.

In the Province of Matanzas, nine or ten miles northwest of Matanzas ,about one mile east of north of the property known as El Recro, now owned by Captain L. H. Mattair, U. S. A., there is an occurrence of asphalt on the north side of a hill. The asphalt oozes out in liquid form and impregnates the surface sands and gravel, cemeting them into a kind of a pudding-stone. It also accumulates in small quantities in ditches which have been dug here for the purpose of testing the yield.

There is no great amount of the asphalt escaping to the sur-

face, although the yield might be materially increased by sinking a shaft on the fissure. It exudes apparently from small fissures in the serpentine near its contact with a hard limestone, the serpentine forming the hill above and the limestone lying on its lower flank. The latter rock has no perceptible odor of asphalt or petroleum, and therefore probably has no association with the origin of the bituminous material.

Another reported occurrence of asphalt is in the vicinity of Guamacaro, between the towns of Limonar and Cardenas.

Chapter VII.

AMERICAN BITUMINOUS LIMESTONE.

AMERICAN natural bituminous limestone has been before referred to as found in Uvalde County, Texas. In a recent report formulated for the United States Bureau of Geological Survey of the Department of the Interior, Mr. George H. Eldridge states that the only deposit worked in this somewhat extensive field is that by the Uvalde Asphalt Company, eighteen miles west of Uvalde, and eight miles southeast of Cline, a station on the Southern Pacific Railroad, with which it is connected by rail.

The limestone quarried primarily consists of what seems to be an assemblage of minute organisms, together with a conspicuous proportion of crystalline calcite. Molluscan remains, often of large size, are also present. Through the mass of the rock there is a high per cent. of interstitial space, which in some instances may even exceed the solid portions. In addition to the interstitial space, properly so-called, are cavities produced by the removal of the molluscan remains and other of vug like character.

These spaces, institial and other, are occupied by bitumen, but it is evident by the many examples throughout the bed that the supply was inadequate to completely fill the intervals provided, or that the channels to the same were blocked before the filling was accomplished. An interesting feature in connection with the larger cavities of the rock is the presence of white, well-crystallized calcite, which has replaced the shells of the molluscan forms originally present, and has also been deposited in secondary form on the walls of the cavities, whether of animal origin or vugs. The bitumen, in passing into these cavities, has filled, in instances, every angle made by the crystalline lining of the walls, and fractures of the rock now yield most beautiful cross-sections.

The asphalt itself has a brilliant luster when fractured, but when, in the broken rock, that portion which formerly was in contact with the walls of the cavities it filled is exposed, the bril-

PHILADELPHIA STREET LAID WITH BERMUDEZ LAKE ASPHALT BY THE FILBERT PAVING & CONSTRUCTION COMPANY, OF PHILADELPHIA.

liant luster is wanting, a surface of dead black replacing it. The material is brittle, and in hardening apparently suffered no shrinkage. The asphaltic limestone itself is tough and unyielding.

Throughout the rock occasional particles of pyrite are observed, and there are instances in which both these and calcite have been caught up and carried on in the flow of the infiltrating asphalt. The molluscan cavities are varied in form and size, and embrace those of both bivales and univalves. Among the former is one resembling a Gryphaea; among the latter, a long, tubular form showing delicate striations on its surface. This especially abounds.

A feature of the bed is the presence of small gray to white bodies of calcite of such close texture that they remained unimpregnated by the bitumen. Such bodies are excessively hard, are lacking in interstitial spaces, and even have the tubes which they, too, carry filled with secondary, earthy and crystalline calcite. In the northern part of the quarry, rock of this composition and texture may equal the more porous, bitumen-bearing portion, imparting to the bed a marbleized and mottled effect.

In this portion of the quarry there is also a transverse or vertical joint plane, which is of interest chiefly because of the impoverishment that has taken place in the bed on either side —on the north to a distance of 8 inches to 1 foot, on the south less. The line between the impoverished and rich portions, as exhibited by their brown and black colors, respectively, is, too, quite as distinct as the joint plane and practically parallel with it throughout.

The amount of bitumen in the rock of this quarry is said to vary between 10 and 20 per cent., 14 and 15 being common, while 20 occurred in one locality in a body of considerable proportions. The structure of the rock has naturally had a most material influence upon the distribution of the bitumen.

The extent of the enriched body of limestone at the Uvalde Company's quarry had not been determined either laterally or in depth, but it could be easily and economically ascertained with a drill, for the position of the bed is at most but a short distance from the surface. The outcrop of the limestone shows it, however, to have been more or less impregnated, and doubtless with important interruptions, throughout an area of several miles.

The area of rock removed at this quarry, though somewhat

irregular, is between 300 and 400 feet in diameter, while the depth quarried averages perhaps 15 feet, the enriched rock below this passing beneath water level. The section of limestone exposed is: At the top, 3 or 4 feet of barren, drab, or buff rock of the composition described as general for the unimpregnated portions of the bed, this everywhere forming the cap; beneath this, a zone 1 or 2 feet thick of impoverished brown rock, breaking more easily than the richer portions below; finally, the bitumen bearing bed of high per cent., 18 feet in full depth to the floor of the pit.

The material from this mine has been used for about 200,000 square yards of street pavement in the cities of San Antonio, Houston, Shreveport, Waco and Palestine, Texas. The heavy freight has prohibited its use in Eastern cities.

The specifications for this asphalt as drawn up by Mr. E. G. Truehart, City Engineer of San Antonio, calls for the natural rock asphalt to contain from 12 to 14 per cent. of natural bitumen, 80 to 88 per cent. of pure bicarbonate of lime, and must be free from quartz, sulphates, iron pyrites or aluminum.

The rock is first crushed and reduced to a powder, after which it must be heated in a revolving cylinder from 250 degrees to 320 degrees Fahrenheit, depending on the time of year and distance to be hauled. Nothing whatever shall be added to or taken from the powder obtained by grinding the bituminous rocks. No binder will be required if this material is used, but care must be taken to leave the top surface of the concrete of sufficient roughness to obtain a good bond.

The powder must be carefully leveled and spread in one continuous sheet in such a manner that it will be 2 inches in thickness after compression. It must be hot when spread, and therefore, if so ordered by the engineer, it shall be brought to the street in boxes that can be handled by two men and dumped at the exact place where it is to be spread. The tamping must begin immediately after the spreading of the powder, at first carefully, and then gradually augmenting the force with tools made especially for the purpose, heated to the proper temperature in portable furnaces.

The entire surface must be thoroughly tamped with hand tampers and then gone over with smoothing irons, till it presents a glossy appearance. Dry hydraulic cement will then be swept over the top, and the surface rolled with a steam roller weighing no less than six tons. The rolling will be first done longitudinally and then

transversely at an angle of 45 degrees from both sides of the street, and continued until the pavement has been thoroughly compressed.

Great care must be exercised in making a proper bond with the surface, which has been already laid and allowed to cool. First all loose and all uncompressed powder must be removed from the edges of the pavement and the joints swept perfectly clean.

A gasoline heater must then be used in heating thoroughly the rough edges of the pavement already laid, before new material is added; the spreading, tamping and rolling then goes on as before, the end intended being to leave no trace of the junction. If so ordered instead of applying the material to the rough edge, the said edge shall be cut with an axe so as to leave a clean smooth joint; this joint must then be well painted with a coating of asphaltic cement before the heated powder is laid against it.

Bituminous limestones are also found in Indian Territory, but of very imperfect impregnation. Of that in the Buckhorn district Mr. Eldridge reports that the rock of the quarry is very massive, with a texture varying between earthy, granular and crystalline. The crystalline texture is the most prevalent in the upper half of the deposit, the earthy and granular in the lower half. The average per cent. of bitumen in the quarried rock is between 5 and 6, based on samples from the stock piles.

Different portions of the bed, however, vary somewhat in richness, that quarried, which is the granular crystalline, being regarded as the most satisfactory. The color is a deep chocolate brown in the more homogeneous, granular, and finely crystalline portions, varying to brownish gray in those more coarsely crystalline; the first described is the richer in bitumen.

The rock is stratified, but the bedding is extremely heavy in the lower middle portion. Near the top and bottom the beds are from 2 to 10 feet thick, and the divisional planes are especially pronounced. Bodies of highly crystalline calcite are irregularly but profusely distributed through the upper third of the mass, and in their poverty in bitumen are in marked contrast to the general rock of the quarry.

About 70 feet from the top of the limestone is a narrow belt in which blue translucent chert abounds, and there is a trace of chert also at the base of the bed.

In the lower portion of the mass as quarried is a zone, about 20 feet in width, that presents the aspect of having originally been

laid down as a calcareous mud. It is of a browner color than the crystalline granular rock, and is regarded of slightly lower value.

In this connection it may be noted that there are many instances of muddy texture in the limestones throughout the Buckhorn district, which, coupled with other features, are suggestive of a sedimentary origin for the greater number if not for all of them.

The effect of the calcite bodies in the upper portion of the limestone upon impregnation is noteworthy, the universally close union of their crystals preventing infiltration into their substance of more than the merest trace of bitumen, and often none whatever. In the portion of the limestone surrounding these bodies, however, infiltration has been free, or at least in proportion to the absence of the calcite structure.

In the Brunswick district there is a quarry of very similar formation, the earthy, granular, and crystalline texture are all repeated; the barren calcite bodies are present, in equal contrast with the general mass of the rock; the calcareous is as readily identified in one locality as in the other, and each variety of rock in texture shows the same difference in the degree of impregnation.

If there be a difference in the rocks of the two localities it is in an apparently more general distribution of the calcite bodies through the rock of the Brunswick quarry and a possible slight lowering in consequence, of an otherwise equally maintained average in the bitumen percentage.

A feature, too, conspicuous in certain portions of the Brunswick pit, is the filling of fracture cracks with pure bitumen, derived, probably, by infiltration from the main body of the rock. This rock has been used for the manufacture of asphalt Mastic which has been laid extensively in Western cities for brewery floors.

SEMI-PORTABLE ACME ASPHALT PAVING PLANT.
Warren Asphalt Paving Company, Cambridge, Mass.

CHAPTER VIII.

BITUMINOUS ASPHALT SANDSTONE ROCK.

NATURAL bituminous asphalt sandstone rock as in contradistinction to limestone, appears to be peculiarly of American origin. It is found in Kentucky, Missouri, Indian Territory, Texas, Utah and California.

The difference between the limestone and sandstone bituminous impregnation appears to be most marked, it is seen that the bitumen softens the limestone and is homogeneous, whereas the bitumen with the sand remain two distinct substances although they can be compressed into a compact mass when heated.

The most important fields operated are those in Kentucky and a quantity of pavement has been laid with the sandstone in Louisville. Professor Eldridge says that bitumens in Kentucky occur as impregnations of sandstones. They are, perhaps the result of exposure in outcrop of oil-bearing strata, the petroleum having thus been converted by loss of the lighter hydro-carbons and by oxidation into a product of asphaltic nature.

The sandstones thus impregnated carry in freshly picked faces of the quarries from 4½ to 7½ per cent. of bitumen, amounts that would, perhaps show material increase at a distance from the exposed surfaces. The horizons at which the bitumens occur include the conglomerate at the base of the coal measures, a sandstone a little above, and the several sandstones of the Chester series of the lower carboniferous. The enriched beds are met in outcrop in many localities in Breckenridge, Grayson, Edmonson, Warren and Logan counties.

In Breckenridge county, The Breckenridge Asphalt Co. has opened two quarries about 100 yards apart, near the point of the ridge between the forks of Lost Run, two miles south of Garfield.

Each is about 200 feet in diameter and shows practically the same section of sandstone, and variation in thickness or in the degree of impregnation being such as may be expected betwen different points in the same bed.

The sandstone is of sharp, fine-grained quartz. Of the 14 feet enriched, the lower 7 or 8 are said to carry an average of 8 per cent. (varying between 6 and 10) of bitumen and constitute the shipping rock. The sample collected by Professor Eldridge contained a little less than 6 per cent. Above this the amount of bitumen is considerably diminished and with exceptions the rock is treated as refuse. There is no distinct line of demarcation between the richer and poorer horizons, a wavy zone of gradation 2 or 3 feet in width existing between the two. This zone affords a certain amount of second grade rock, to which is occasionally added material of equally low per cent. that may chance to occur in the underlying portion of the bed. This second grade rock is then occasionally made available by thoroughly mixing it with the highest grade from the mine.

A feature of interest—not only in the Breckenridge quarries but in all visited—is the impoverishment that takes palce for 6 or 8 inches on either side of joint planes. Beyond this the rock maintains its average bitumen contents.

In Grayson county exploitation has been made by Schillinger Bros. and Dr. Wilham F. Breyfogle. One of the Schillingers' mines at Black Rock produces a rock which is a medium-grained massive sandstone, of a thickness of 8 or 10 feet, the lower 5 of which is impregnated with bitumen to an average of perhaps 6 per cent. distributed in greater proportion through the lower 3 feet of the mass. Of the Breyfogle quarry near Tar Hill Professor Eldridge reports that the rock is a sandstone composed of medium to coarse grains of quarty, much coarser, as a rule, than the material of the Leitchfield flag. The latter rock is also generally thin bedded, hard, and durable, and makes an excellent flagging, all in marked contrast to the features of the Big Clifty sandstone.

The impregnated zone at the Breyfogle quarry, embraces a thickness of about 10 feet in the upper portion of the Big Clifty sandstone. Of this the lower 5 or 6 feet are of sepecial richness carrying a somewhat variable amount of bitumen, indeed, but, perhaps, an average of 7 per cent. Upon passing under greater cover

it is quite possible that the upper portion of the zone will show an increase in its contents.

Between the two portions there is no definite line of division. An incidental feature at this quarry is the heavy cross bedding, irrespective of which, however, the bitumen appears to have impregnated the rock to a general level, thus making productive at one point a layer that is apparently unproductive at another. Another feature is the degree in which the bitumen seeps from the exposed faces of the quarry, even from levels in the sandstone where there are no visible division planes.

Where crevices, either natural or formed by blasting, have remained open, such seepage becomes of added interest as a possible suggestion regarding the formation of gilsonite and other veins of related material. The bitumen, always of a highly gummy consistency after leaving its bed, is seen slowly trickling from the sides of the crevice, deposting one layer over another, yet the several layers blend in a homogeneous mass but a short time after the flows. Held in the bitumen, also, are small rock fragments that have tumbled into the crevice and have been taken up by the slowly flowing mass. Such material is now hard, even semi-brittle in instances.

In Edmonson county the geological horizon of the bituminous sandstone of the Bee Spring region was traced by Mr. S. D. Averitt from Leitchfield, 15 miles north. The same succession of beds is encountered in this section as in the region of the Schillinger No. 2 Prospect, but in more extended order. The roofing limestone of the Chester appears at Harold Hill, 5 miles south of Leitchfield. It is here about 6½ feet thick and rests upon 6 to 8 inches of marl. It has the same lithological and paleontologic characters as in other places in western Kentucky.

There are many deposits of bituminous sandstone in this part of Edmonson county, and in many places small tar springs, rather than saturated sandstone, are found. One deposit of considerable extent is found 2 miles northeast of Bee Spring, on the farm of Mr. J. Meredith, and another 1½ miles south of Bee Spring. None of the deposits are worked and their value is undetermined.

The deposits already described are found along the eastern border of the coal measures; those that follow occur along the southern edge of this area. The deposits of bituminous sandstone in Warren county are confined to its extreme northern end, the

lower coal measure—Chester terrane entering it only to a limited extent. But two quarries are opened within the county, neither, however, more than a prospect.

They are located on what is known as the Cherry Farm, at Youngs Ferry, on Green River, 12 miles north of Bowling Green.

Two openings, about 300 yards apart, have been made in the bituminous deposits of this locality. One, the eastern, near the summit of the ridge, is being developed by the Green River Asphalt Co.; the other, the western, is controlled by the Sicilian Asphalt Company, but has remained idle since the shipments of a few tons of trial rock.

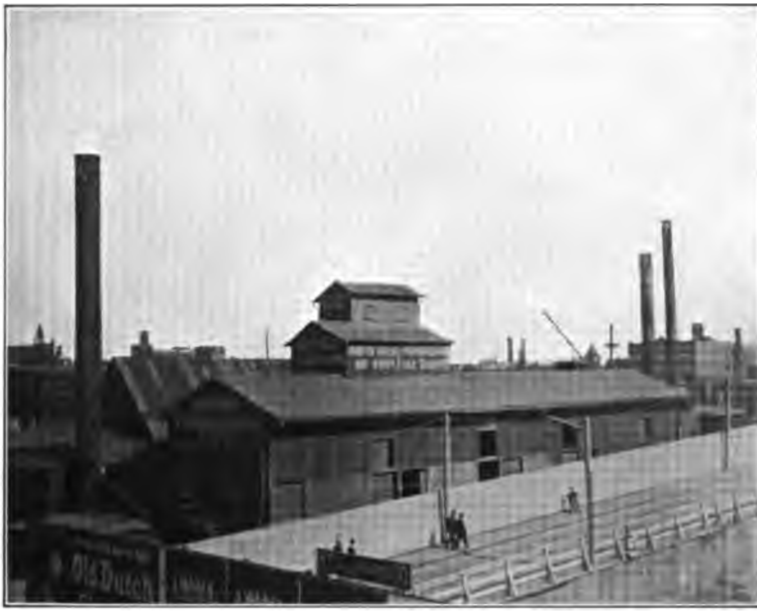
This latter deposit, an impregnated zone in the basal conglomerate of the carboniferous, is about 10 feet thick and occurs about 15 feet beneath the top of the stratum. The enriched rock continues for an undetermined distance to the west, but on passing eastward the bed seems to become barren; this, too, within a few hundred feet.

The matrix of the impregnated zone is essentially quartz sand, a few pebbles being distributed through it in small assemblages here and there. As in other instances, the lower half of the zone is the richer, carrying at the old quarry breast about 7 per cent. of bitumen. The bitumen continually seeps both from the face of the small openings and from the out-crop, forming small pools a few inches across at the base of the ledge.

The deposit of the Green River Asphalt Company is in the bitumen bearing sandstone overlying the main basal conglomerate, from which it is separated by 20 to 30 feet of yellow and gray shale.

The bed, as exposed at the time of examination, showed a thickness uncovered of about 6 feet, all impregnated, but in varying degree, the lower 2½ feet of excellent promise. The sample taken by Mr. Eldridge within 5 or 6 feet of the outcrop, yet in normal looking rock, yielded about 7 per cent. of bitumen. At one point the upper portion of the bed, also, showed considerable enrichment, indicating that upon passing beneath cover the entire 6 feet might become available for shipping. The matrix of the rock is a clear, sharp, quartz sand.

The deposits of bituminous sandstone in Logan county lie in its northern half, in the Chester division of the lower carboniferous. A single quarry, that of the Standard Asphalt Company, has



ASPHALT PAVING PLANT OF THE ASPHALT CONSTRUCTION COMPANY, OF NEW YORK.

been opened, about 5 miles northeast of Russellville, in the Big Clifty sandstone. There is also a prospect about 2 miles northwest of this at the same horizon. Mr. Averitt also reports one or two other deposits, unopened, at this horizon, near Homer, still farther north.

The region about Higginsville, Lafayette county, is the only portion of Missouri in which bituminous rock has thus far been found, with a possible exception near Odessa, 15 miles west, where also, evidences are said to exist. The only attempt at development has been by the Higginsville Quarry Company, on land near the Soldiers' Home, 1½ miles northwest of the town, where a pit 20 feet in diameter has been made for trial purposes.

California has several deposits of bituminous sandstone and of malthas in sand. The City Street Improvement Co. has extensive quarries near Santa Cruz. The bituminous sandstones which constitute the product of these quarries are essentially an aggregate of minute to medium-sized quarz grains. In addition to these, there is a slight admixture of a feldspar like material suggestive of the derivation of the sediment from the adjacent granite area. There is also present at times a slight amount of iron and a clayey looking material in fine grains.

Only the quartz, however, is conspicuous. This is subangular to rounded. It is in the interstices of this rock that the bitumen is held to an extent of between 14 and 16 per cent. in the average specimen. The rock varies somewhat in hardness, but on the whole is soft, crumbling under the sun's heat, very tenacious, and gummy to the touch. Its color is normally black to brownish-black, weathering to a gray on exposure to the atmosphere. As to the coarseness of the material constituting the bed, while the mass of it is of a medium grain, there are bodies of small extent of coarser stuff, imparting a gritty and at times even a fine conglomerate appearance, the pebbles also being of quartz, though occasionally one of clay is found. The temperature of the atmosphere, according as it is cold or hot, renders the rock either brittle or soft.

There is but little variation from the above features in the quarries that are opened on the main bed at the lower horizon. Moreover, the members of this bed themselves varied but little from each other. The company has laid several streets with this material in Santa Cruz and some in San Francisco. I understand,

however, that they have lately laid the ordinary street mixtures prepared in eastern cities, using the California pure bitumen with sand added. This is from the fact that freight rates are too expensive to allow of any distant freightage on the natural material.

The same trouble exists in the use of the Kentucky bituminous limestones and it can only be used to advantage in the neighborhood of the mines or in places where exceptionally low rates of transportation are obtainable.

CHAPTER IX.

MANJAK AND UINTAITE.

BARBADOS produces a bitumen which is known as manjak, the origin of this nomenclature is indeterminable, it is a purely local term and may have been given by the negroes or possibly have been handed down from the Indians who inhabited the island prior to 1605, when the crew of the "Olive Blossom" took possession of the Island in the name of "James King of England and of this island."

The geology of the Island does not seem to afford the positive source of the bitumen. From one point of view the land rises in a succession of limestone and coral terraces which indicate different periods of upheaval from the sea. From another there is nothing to be seen but a mass of abruptly rising rocks.

The gullies or ravines, the result no doubt of volcanic agency, are very numerous radiating from the high semi-circular ridge of the Coralline formation in a very regular manner to the west, north and south but not to the East, where the coral rocks end abruptly.

The chalky soil of the district called Scotland (from its assumed resemblance to the scenery of the Highlands)contains "infusoria" and is altogether different from the deposits of the coral anmials which form the superficial area of six-sevenths of the island (91,000 acres). Besides the chalk or marl, sandstone is found in this dtstrict.

The Scotland formation also contains a blue clay sometimes interstratified with the sandstone. It is in this section of the Island that the bitumen was found and to Mr. Walter Merivale, C. E., must be given the credit of exploiting the sources and developing the industry of mining the product.

In a paper read before the Federated Institution of Mining Engineers, Mr. Merivale stated that having found the manjak in pockets apparently in no great number and of no great size, he considered that it suggested the fact that the mineral found in the

pockets must have broken off a main body and later having found a vien where the ground was not disturbed by slips, his conclusion was that there is beneath the island an enormous reservoir of liquid bitumen which is still trying to force its way to the surface.

In the Conset district, there is a hill, or rather a piece of the vliff, about 300 feet long, on the coast, called Burnt Hill, which is described by Messrs. Jukes-Browne and Harrison, in their pamphlet on the geology of Barbados, as being impregnated with bitumen. Impregnated it certainly has been, but the impregnation took place very many feet below the level it at present occupies, and before it was thrust up through the calcareous sandstones and marls. These still stand on either side of it in alternate strata, from 3 to 12 inches thick, exposed on the face of the cliff, and rapidly and more rapidly inclined upwards as they near the intruded mass of shale. The shale, moreover, shows no stratification, but is simply a huge mass. Mr. Merivale sunk shafts on both sides of it and found it below the marl. This shale or bituminous clay, has the following analysis:

Moisture	7.52
Ash	76.19
Carbon	14.32
Hydrogen (not included in moisture)	1.05
Oxygen, etc.	0.92

As the shaft increased in depth thin veins of hard manjak were found, and others of liquid manjak, and of semi-liquid manjak. In the Conset district, the coral capping has been removed, and the manjok exposed in more than one spot.

When met with, some way below the surface, the blue clay is soft and treacherous, the fissues, which divide it up into a million blocks, contain bitumen or water, and the blocks slide from their places as soon as the miner's pick removes the supporting rock or manjak from before them. Higher up, the blue clay seems to be almost a different formation, and is as hard as rock, not unlike chalk, and crossed and recrossed by thin streaks of manjak and of gypsum.

Large quantities of iron pyrites are also found here and there in it, in nodules and in very thin veins.

The manjak veins are thrust up through all the formations except the coral, which probably indicates that the intrusion oc-

EAST COMMERCE STREET, SAN ANTONIO, TEXAS.
Laid with Uvalde Natural Rock Asphalt Powder.

curred before the coral was formed, or it may mean that it occurred after it was formed, but was unable to get through it. In the latter case, however, the ends of the veins would be flattened out against the bottom of the coral, instead of ending in thin streaks in the softer lower formation.

The rain having washed away this lower formation after the removal of the coral cap, the thin outcrop is exposed, and at times a stream cutting its way down a hillside, carves out a piece of the vein that crosses its path, leaving exposed a section of the vein on each side of the gully; or the waves eat away the cliffs, and exhibit the cross section of a vein running out to sea.

It was upon one of these stream exposed veins that Mr. Merivale began work a few years ago, and it is from this vein or pocket, as the geologists are understood still to call it, that he has extracted a large tonnage.

The following are analyses of Merivale manjak and of Trinidad glance-pitch:

	Merivale manjak.	Trinidad Glance-pitch.
Specific gravity	1.123	1.139
Melting point	420° F.	360° F.
Matter soluble in carbon bisulphide	97%	88%
Ash	2.32	7.44
Ash, color	Reddish.	Grayish.
Loss on heating	2.61	9.4*
Iodine absorption	42.2%	42.0%
Organic dust	0.69	4.56

*Per cent. after heating to 500° F. for two hours.

Others have followed Mr. Merivale's example and have mined the manjak which is in good demand for insulating material, varnishes, waterproof, etc., and it has to a great extent, superseded for use in high class varnishes Egyptian and Cyrian asphalts, which it closely resembles in composition and appearance. This asphalt has not had the advantage of the extensive advertising given to other bitumens and the writer does not call to mind the exhibit of this mineral at any of the great expositions.

Possibly the advantages of this method of bringing products

before the public is not as popular as hitherto, for it was noticeable that at the Pan-American Exposition only one exhibit, that of the Barber Asphalt Co., was on view, while at the Chicago "World's Fair" a great number of companies were represented.

Uintaite (gilsonite)is a similar material to the Barbados man-jak; it is found in the vicinity of the boundary line (between Colorado and Utah). Professor Eldridge has described it as a black, tarry-looking substance of most brilliant luster, normally of absolutely homogeneous texture, and exceedingly brittle. Its fracture is coarsely conchoidal. In mining, it gives off a fine chocolate brown dust, most penetrating to skin and lungs. Sufficiently near the outcrop of the vein to be influenced by atmospheric agencies, it loses its brilliant luster for a dead black surface, but a fresh fracture, no matter in how small a particle, shows its brilliancy still present, indicating a change to an inconsiderable depth only.

Under atmospheric influences, also, uintaite shows a fine columnar structure at right angles to the walls of the vein and to a distance of about 6 inches from them. This structure has been recognized by Wurtz, Lesley and others in grahamite, and by Lesley is called "Pencillate." In addition to the columnar, there may be developed a cuboidal structure, in some instances by a further transverse separation of the pencillate rays in others independent of these. In the upper 10 or 15 feet of a vein the latter structure not infrequently prevails through a large proportion of the uintaite, shading laterally into the two pencillate zones at the sides. It would seem quite probable that this structure, pencillate and cuboidal, is inherent in the material having originated perhaps immediately after its injection into the fissure from cooling or from pressure.

The walls of the uintaite veins are usually impregnated with the mineral to depths of from 6 inches to 2 feet, though the shales, on account of their close texture, do not permit this to such a degree as the sandstones. The line between the impregnated and non-impregnated portions of the wall rock is usually somewhat indefinite, but instances are not wanting of the sharpest demaracaiton.

The region in which the unitate (gilsonite) veins are found extends between the parallels of 39 degrees 30 minutes and 40 degrees and 30 minutes, and the meridians of 109 degrees and 110 degrees 10 minutes, or from a point 4 or 5 miles within the Colorado

line, westward for 60 miles into Utah. Larger veins are somewhat scattered, one lying about 3½ miles due east of Fort Duquesne, a second in the region of Upper Evacuation Creek, and the two or three others of chief importance in the vicinity of White River and the Colorado Utah line. Besides these, there is a 14-inch vein near the western edge of the area in the vicinity of the fortith parallel; another of equal size about 6 miles southeast of the junction of the Green and White rivers; a third in a gulch 4 or 5 miles northwest of Ouray Agency, west of the Duyuesne River, and a number from one-sixteenth of an inch to 1 foot in thickness in an area about 10 miles wide, extending from Willow Creek eastward for 25 miles along both sides of the Green and White rivers.

Chapter X.

LATE EUROPEAN WORK.

WHILE preparing this matter the author made a trip to Europe and took the opportunity to study there the developments in the asphalt industry. He visited Mr. W. H. Delano in Paris, whom he found busy in the preparation for putting up works on the Mahmoudieh Canal in Alexandria, Egypt, where his company have a considerable amount of work to do in compressed asphalt.

A model of bituminous concrete fortification attracted the writter's attention and he was informed that a casement 12 meters by 6 metres by 4½ metres had been constructed of the same material for the French arm officials in 1886 at the Bourges Camp (Department Cher), at which bombshells charged with melinite had been fired and that the construction stood the test for fifteen minutes, while one of the same built of hydraulic cement concrete was shattered at the first discharge.

In London the writer mėt Mr. H. D. Blake, director and general manager of the Limmer Asphalt Paving Company. He stated that Limmer mastic and asphalt and Montrotier Seyssel mastic asphalt are mineral rock asphalts prepared only by the company. The ungritted mastic asphalt is composed of not less than 15 per cent. of bitumen and 85 per cent. of fine rock asphalt powder. The gritted mastic asphalt is composed of 15 to 18 per cent. of bitumen and from 82 to 85 per cent. of fine rock asphalt powder, with an addition of from 10 to 20 per cent. of fine specially prepared grit, according to requirements.

The various purposes to which this company's mastic asphalt may be put are almost innumerable, and to merely mention a few, Mr. Blake states that these mastic asphalts are being very largely adopted by architects, and engineers for roofs, floors, bridges, barracks, fortifications, powder magazines, quays, wharves, barns, footways, pavements, graneries, drill-grounds, breweries, stables, coach-houses, courtyards, railway platforms, warehouses, basement floors, covering of railway and other arches,

TRIMBLE PLACE, NEW YORK, N. Y.

Paved with Neuchatel Rock Asphalt Paves, finished with Non-Slippery Wearing Surface, cast iron gutter and wheel plates.

damp course to horizontal walls, vertical work to face of walls, swimming baths, skating rinks, tennis courts, lining reservoirs, slaughter houses, market places, piggeries, dog kennels, garden paths, and playgrounds to public schools of the Metropolis and leading provincial towns in the United Kingdom of Great Britain.

Mineral rock mastic asphalt does not absorb impurities and can easily be cleansed, and its introduction into Indian and other eastern cities would do much to facilitate the work of sanitation now so much needed in the East, especially for the lining of the usual open side drains and filth carriers of the bazaars.

The substitution for the rough and imperfect brick gutters, of a smooth jointless surface of mineral rock mastice asphalt would prove invaluable, and would do much to remedy their present offensiveness and danger.

Again, mineral rock mastic asphalt used for floors for public and private latrines is, for similar reasons, much superior to any other kind of flooring, especially on account of its durability, the ease and rapidity with which it can be cleaned or repaired, and not least, its great sanitary properties, because being jointless no vegetable or animal refuse can lodge in crevices and decay. Mineral rock mastic asphalt might, with advantage, be introduced into Indian and other eastern hospitals, barracks and public buildings as floors, flat roofing with skirting and angle fillets, damp-proof courses, vertical work with hot asphalt applied to walls, also for damp vertical walls where asphalt mastic plates are fixed and afterwards jointed with hot liquid asphalt.

Thus walls and foundations are made secure against dampness of any kind, because after its manipulation the mastic asphalt becomes impervious to air and water, resists fire, does not burn, repels vermin, checks vibration and is a non-conductor, and should do much to arrest the ravages of rats and white ants and their destructive effects of rot in foundations.

Many other situations in which mineral rock mastic asphalt may be advantageously used will readily suggest themselves. It may be mentioned, however, that the Limmer Asphalt Paivng Co.'s mastic asphalts have been laid in India, Ceylon, China, South Africa, etc., establishing the fact that mineral rock aspahlt is, in the end, a real economy, and when properly laid withstands the extremes of heat, cold and damp, successfully.

Mr. Blake considers that all horizontal foundation walls to

buildings should be covered with a thickness of ½ inch of mastic asphalt below the ground level to prevent dampness from arising. Vertical walls below ground level should be covered externally by applying a thickness of ¾ inch vertically, viz., by pointing the joints of brickwork with hot mastic asphalt, then applying two separate coats against the wall, making in all an average of ¾ inch in thickness. Particular care should be taken to connect this vertical asphalt with that laid horizontally by adding an angle fillet. Amongst many other places that might be named where this class of work has recently been most successfully executed, are the horizontal and vertical walls of the new Admiralty Buildings, Whitehall.

Where walls under ground level are of a very damp nature, and it is impossible to put up the liquid mastic asphalt in the ordinary manner, the Limmer Asphalt Paving Company for some years past have introduced their special system of mastic asphalt plates which can be easily, economically, and successfully used, viz., after the mastic asphalt plates are made to the proper size, and the backs of which are specially roughed to form a key, the joints of the wall are raked out and a thin bed of cement mortar laid on the back or rough part of the plate and pressed against the wall, fixed in courses with broken joints. When the cement has set, make good the joints with hot mastic asphalt; the whole then becomes one solid sheet and is not only damp proof but adds considerable strength to the walls.

The same care must be taken in making good the connection of the vertical plate work with the horizontal damp course by adding an angle fillet. These plates are recommended for all walls, either internal or external, but in all new buildings it is a great advantage to execute the work externally.

This method is particularly suitable for lining internal and external damp walls, reservoirs, sewage tanks, strong rooms, etc. In the year 1890 this company supplied asphalt for lining the Malabar Hill Reservoir, Bombay, and sent out a foreman to superintend the work, which was carried out to the complete satisfaction of the authorities.

It has always been a difficult matter to lay with any success asphalt over suspension bridges, especially on account of the excessive vibration. This company, however, recently covered with their mastic asphalt the carriageway of the well known Clifton

Suspension Bridge, near Bristol, England, and successfully got over the difficulty by covering the wood flooring with canvas, well nailed down, so as to form a surface to receive the mastic asphalt, then laid ½ inch of rich bituminous mastic as an elastic bottom coat, following with a second layer of less bituminous mastic 1 inch thick, making in all 1½ inches in thcikness. At special intervals, an elastic bituminous joint was specially inserted 1 inch in depth, made transversely to prevent the mastic asphalt from cracking. This new departure has proved exceedingly satisfactory, the carriageway not suffering at all during the severe and violent gales of wind to which this bridge has since been exposed.

In covering a suspension bridge with a steel bent plating bottom as a foundation, it has been proved that by filling in the hollows with Portland Cement Concrete, so as to form the camber to receive the mastic asphalt, the cement concrete does not withstand the vibration and eventually cracks and crumbles into dust.

This company recently covered the carriageway and footways of the Menai Suspension Bridge over the Menai Straits, North Wales, and instead of cement concrete, laid down their bituminous rock mastic asphalt concrete, by filling in the hollows of the plating to the proper formation of the carriageway, and laid the mastic asphalt in two coats in the usual manner with great success.

In Hamburg the writer met, at the office of Messrs. Prins & Sturken, agents of the "Industrie-Gesselschaft fur Steine und Eredn" of Madgeburg, the then managing director of that company, Mr. Bruchmann, who informed him that his company was a new addition to asphalt producers and that it possesses collective mining prerogatives over 420 acres, in Madgeburg, and works the crude asphaltum beds there on mining principles.

Magdeburg Asphalt is the name under which the Asphalt Products of the Industrial Society for Stone and Earth is known in America. The first importation of their mastic was made by the Boorman Anderson Asphalt Co. in 1904, and from 1905 to 1908 a large quantity has been shipped from Hamburg and Bremen to New York and Philadelphia, and it has been used extensively in Western Packing Houses and in such work as the Hall of Chemistry of Syracuse University and on the esplanade of the famous Stadium of that institution.

So far as the Asphalt Industry, in covering its necessities for Mastic, Stamping Asphalt, Asphalt Slabs and Goudrons will de-

pend on German sources, it can only do so by the occurrence of the above minerals near Lobsann (in North Alsatia, District of Weissenburg and about 1½ hours distant from Worth), or through the well-known works at Vorwohle (in the Duchy of Brunswick, District Holzminden), or those of Limmer (near Hanover).

Prof. E. Dietrich, of the Royal Technical High School in Berlin, has therefore in his work on "The Asphalt Streets," in 1882, rightly anticipated "that the Vorwohle Rock Asphalt in respect to its employment as a material for making streets is possibly destined to play a part."

The chemical analyses of the European Crude Asphalt Rock gave the following comparative results. (See Table V.)

TABLE V.

ANALYSES OF CRUDE ROCK ASPHALT.

	Rock Asphalt from German Materials:	Pure Bitumen per cent.	Carbonate of lime per cent.	
	Lobsan	12.32	71.43	*
	Limmer	14.30	67.00	*
Vorwohle	Industrie Ges.	10.62	87.14	**
	Deutsche Asph. Ges.	2.40	91.85	†
	Hannov. Bau Ges.	5.80	89.87	†
	Haarmann & Co.	2.90	90.64	†
	Rehder & Co.	1.40	91.52	†
	Thomae	0.90	93.75	†

Industrial Society for Stone and Earth, Limited, in Eschershausen (Krs. Holzminden).

Rock Asphalt from Foreign Materials:	Pure Bitumen per cent.	Carbonate of lime per cent.	
Val de Travers	10.15	88.40	*
San Valentino	8.83	80.00	‡
Ragusa	8.92	88.21	*
Mons	10.20	84.63	†
Pont du Château	11.40	77.52	†

N. B.—Analysis results:
* according to Dietrich.
** according to Dr. Fritsch & Venator.
† according to our own factory laboratory.
‡ according to Experimental Station in Forli.

SIDEWALK CORNER OF SMITHFIELD STREET AND 5TH AVENUE, PITTSBURG.
Laid with Kentucky Rock Asphalt Mastic by The Wadsworth Stone & Paving Company.

The Vorwohle and Limmer works have united and formed a syndicate in the Vorwohle Asphalt Verkaufs Verein (Society for the sale of Vorwohle Asphalt) to which at present belong the mines and factories of R. Thomae, Rehder & Co. (Vorwohle Asphalt Co.), L. Haarmann & Co., the Deutsche Asphalt Actien Gessllschaft, the United Limmer and Vorwohle Rock Asphalt Company and the Hannoversche Bau Gesellschaft.

The Asphalt mining district belonging to the Industrial Company comprise about 420 Brunswick Morgen of 2,500 square meters = 105 hectares, that is, they alone possess more Asphalt land than all the other Vorwohler Asphalt works taken together. The borings carried out up to the present, and other mining operations, have proved that their Rock Asphalt exists in a thickness of eleven metres, of which only about four metres square are worked first of all, in the first level by means of galleries and drifts as well as transverse headings. According to the report of Dr. F. Rinne, Professor of Geology, and Mr. Hoyer, Mining Engineer, both of the Royal Technical High School in Hanover, the rock which has been already reached suffices for at least 40 years in its whole extent, supposing the output to be daily 10 double loads.

Their Asphalt Rock and crude powder are especially adapted for mixing with the fatter foreign Asphalt material from San Valentino, Mons, etc., on account of their considerable yield of bitumen and high percentage of lime, as well as the perfect freedom from deleterious secondary substances.

For their Asphalt Mastic they guarantee at least 14 per cent. bitumen, which, according to experience, means a considerable saving in Goudron when renewed preparation for laying streets is in question. All authorities agree in the opinion, that the single particles in the asphalt limestone, as well as in its later products, viz.: Mastic, Stamp asphalt, etc., are no longer held together by molecular cohesion, or by a stony cement but only by the asphalt as a bituminous cement. Thus this bitumen guarantee is of the highest importance for every one using Asphalt, on account of the resistance, elasticity and durableness of the Asphalt materials employed in street laying and for other purposes.

Brunswick Asphalt Mastic.—This material has been imported for the last thirty years by Gabriel & Schall, of New York. It has been laid in many public and private structures throughout the

United States, and has proved eminently satisfactory to the owner, architect and contractor.

To insure the protection of the trade, the genuine material is put up in cakes cylindrical in shape, weighing from 54-55 lbs. each, and branded under the registered trade mark (G & S).

By permission of the importers we present the analyses shown in Table VI. on this and following page:

TABLE VI.

ANALYSES OF BRUNSWICK ASPHALT ROCK, ASPHALT MASTIC AND ASPHALT PAVEMENT.

Brunswick Asphalt Rock.

Asphaltic bitumen, per cent	9.70
Carbonate of lime, per cent	90.30
	100.00

Brunswick Asphalt Mastic.

Asphaltic bitumen, per cent	15.42
Carbonate of lime, per cent	84.58
	100.00

Brunswick Apshalt Pavement.

As laid in basement of 276 Canal Street, New York City:

Asphaltic bitumen, per cent	13.44
Grit, per cent	35.00
Carbonate of lime, per cent	51.56
	100.00

COMPARATIVE ANALYSES.

Neufchatel Rock, asphaltic bitumen from 12 to 13 per cent.
Seyssel Rock, asphaltic bitumen from 8 to 9 per cent.
Brunswick Rock, asphaltic bitumen 9.70 per cent.

COMPARATIVE TESTS OF THE ASPHALT ROCK SUBMITTED TO HEAT.

Seyssel Rock disintegrates at 250 degrees Fahr.
Brunswick Rock disintegrates at 250 degrees Fahr.
Neufchatel Rock disintegrates at 200 degrees Fahr.

TABLE VI.—Continued.

COMPARATIVE TESTS OF THE THREE ASPHALT MASTICS SUBMITTED TO HEAT.

The results are identical for all three.
Malleable at 90 degrees Fahr.
Soft at 100 degrees Fahr.
Plastic at 250 degrees Fahr.

The fire tests were also applied to the different Mastics with equally good results.

Fire tests, Neufchatel Mastics, 315 degrees Fahr.
Fire tests, Seyssel Mastic, 330 degrees Fahr.
Fire tests, Brunswick Mastic, 320 degrees Fahr.

CONCLUSION.

The above results are evidences of the similarity of the three named Asphalt Mastics, and the Brunswick Asphaltic Rock is almost identical with the Seyssel Asphaltic Rock.

(Signed) E. J. De SMEDT, Chemist.

In regard to this class of Mastic, so many inquiries have been made into the Modus Operandi that the following practical instructions, prepared by David E. Sayre, when Superintendent of the New York Mastic Works, are appended:

Kettle will lay about 100 to 105 feet 1-inch work. Dimensions: Drum, 3 feet 6 inches high; kettle, 1 foot 7 inches deep and 3 feet 4 inches wide. Use about 14 blocks Mastic and about 50 pounds Bitumen, with about 600 pounds Grit for ordinary outdoor walks. For indoor work about 13 blocks Mastic, 80 pounds Trinidad and 600 pounds Grit for floors that will be used severely by setting chairs, etc., on them. This would not do for a cold cellar. For this use the same combination as for outdoor work, or you are liable to have a crack in the asphalt. For this indoor work you should see that the kettles are thoroughly and almost continually stirred, and particularly from the outside of the bottom of the kettle. The stirrers should be driven down, scraping the side and bottom of the kettle. You should have also a scraper with handle about 54 inches long, scraper about 3 inches wide, scraper made from best steel, and kept sharp, with which to

scrape the sides and particularly the bottoms of your kettles each evening until the iron shows plainly. When the kettles are warm have a board laid across the top of kettle, the bottom chopped and scraped clean with the long-handled scraper. We would suggest for quadrille work to have four additional squares added to your stamp, start your line and set stamp first time straight, then each additional time set two blocks over the last figure made in the work. This, with a little care, will keep your lines straight without using the line more than once. We think you will find kettles made in one piece preferable to those with loose bottoms; also have a heavy angle iron around the top and bottom of the drum, projecting inside. This supports the kettle on the top and strengthens it on the bottom, also leaving a smooth surface so the drums will roll easily. Have your kettle fit in drum neatly, but not too tight, so they will not spill out in rolling and yet can be taken out and put in without too much trouble. The stirrers should have a face about 7 inches wide and scraping edge about 2 to 2½ inches and kept fairly sharp.

In laying asphalt always be sure that the concrete is fully up to grade line and a level, even surface, as cement and sand are much cheaper than asphalt, besides a spreader cannot do first-class work when attempting to spread uneven thicknesses of asphalt. You do not need an absolutely smooth surface, but an even one without depressions or bumps in it, and not too dry. Try and lay the asphalt before the concrete turns white, and just after it has set firmly, as it will blister from the concrete being either too wet or too dry. You will find the above proportions for indoor work will cause complaints from your labor, as it will be very stiff and will require extra hard work to either stir or spread, and will require good strong men, and should be well rubbed with sand. The men may kick, but your work will be satisfactory to the party having you do the work and a source of satisfaction to you as well.

Be careful that the asphalt does not get burned in the bottom of the kettle. It is a good idea to have the last few shovels of material emptied into another kettle, and well stirred into it. We find one never gets the kettles stirred too much after the grit is put in before that it is not so necessary. In laying good stiff work use ¾-inch iron guide bars, and you will get your full inch, and on down for thinner layers; only you will find your material will

PARK AVENUE, CINCINNATI, OHIO.
Surfaced with Kentucky Rock Asphalt by The Wadsworth Stone & Paving Company.

have to be softer as it is laid thinner, and to make it so requires more Mastic and Bitumen or Trinidad. Always see that the joints are well heated before final sprading, keeping some hot stuff ahead of the work on the asphalt the spreader is joining; rub joints extra well.

Chapter XI.

TURKISH AND OTHER BITUMENS.

WHEN in London I found that a Trukish bitumen was being used for fluxing purposes and since had the pleasure of meeting Professor J. Edward Spurr, of the U. S. Geological Survey, who had just returned from Constantinople. He furnished me with the following interesting information:

On the southwestern coast of Asia Minor, north of Cape Chelidonia, is the famous ancient Chimæra of the Greek stories. Here gases are continually disengaged from fissures and are known to have been burning for 2,800 years atleast, for the phenomenon was described by Hesiod before the time of Homer. Tchiatcheff, the Russian geologist, states that the gas is emitted from fissures in serpentine (altered igneous rock) intrusive into limestone.

It is interesting to note in this connection that burning fountains of gas were long known in the Baku oil fields, beforethe discovery of oil there. There is also on the coast of Albania (east shore of the Adriatic) the locality Polina, near Durezzo, where gas emanates from the summit of a hill and often accidentally takes fire. The hill is said to be igneous, but the existence at the foot of it of an asphalt spring suggests an organic rather than a volcanic origin for the gas. Petroleum also has been reported from here and seems to have been exported on a small scale. This hill was the ancient Apollinia, and here the priestess of the famed Delphic oracle sat and inhaled the fumes of gas, till dazed, when her words were regarded as inspired.

It is, therefore, an open question as to whether the escaping gas of the Chimæra (the modern Turkish name is Yanartash "stone that burns" is of organic origin, and indicates oil below, or is volcanic; but the chances are perhaps in favor of the former alternative, especially as the igneous rocks of the locality (altered peridotite) is not one that indicates recent volcanic activity.

As is perhaps most often the case, there seems to be a general connection between petroleum and natural asphalt in the Turkish Empire. Asphalt deposits are known in a number of lacalities, of which the best known are in Albania, near the Adriatic and in Palestine.

In Albania asphalt occurs at the foot of the hill of the Delphic oracle, as mentioned above, also in a large bed near Avlona and other places. This asphalt was mined by the anceints and is mentioned by Posidonius. The chief producing locality is now Selinitza, which is worked by the Imperial Ottoman Bank. The asphalt is not of the highest quality, bringing about $13 a ton in Trieste. Asphalt is reported from the Province of Monastir in European Turkey.

The asphalt in the region of the Dead Sea (Lake Asphaltites) has long been noted. There are bituminous springs at Nebi Musa which contain 30 to 40 per cent. asphalt.

What is commercially known as the Syrian asphalt is exploited near Hasbaya, in the Province of Damas, by the Civil List of the Sultan. The mineral is hard and of a brilliant lustre, with a marked odor. It is of great purity, and is, therefore, used entirely in the manufacture of varnishes and aniline dyes. It has been chiefly marketed at Trieste, where it is quoted at $84.00 per ton, boxed and delivered. The demand is, however, limited, so that the yearly output is only a few hundred tons.

An Anglo-German company with headquarters in Constantinople, has been formed to work other deposits in Palestine, but so far they have not obtained the concession.

Bituminous schists are found near Beyrout. Some movement has been made towards working them and a large trial lot has been sent to England, but so far there has been no real activity.

Dr. Edgar James Banks, formerly American Consul at Bagdad, and now director of the Urarchaeological Exploring Expedition, states that there are springs of bitumen opposite the town of Nasarieh, Province of Busreh, about 100 miles from the site of Babylon. The deposits are near a navigable river, but are not exploited, save that the material is to a certain extent used by the natives as a cement in building, and as a substitute for sealing wax.

In Amsterdam, the writer went over the works of the Neuchatel Asphalt Co. with the resident manager, Mr. J. Patten

Walsh, who pointed out one of the recent improvements in the laying of compressed asphalt streets through the use of mastic adjoining tramway rails and where the asphalt pavement came in conjunction with pavements of other material. Repairs to the asphalt streets necessitated by gas leakage attracted attention as in streets laid ten years there were no other defects.

A report on this subject by Dr. James C. Bayles, M. E., at a Convention of the League of American Municipalities is interesting in this connection. Dr. Bayles says that in case of asphalt, the destruction due to gas leakage is rapid and complete. The first surface indication is a depression marked with parallel striations in the direction of the movement of traffic. This indicates that the binder has been decomposed, allowing the superficial layer to yield under the wheels of vehicles. A bar hole put down through such a spot will always find a gas leak. Gas may also be found in large quantities under sound asphalt—a phenomenon which has given rise to some confusion.

The explanation is really very simple. What rots the binder of the asphalt pavement is neither the hydrogen nor the carbon monoxide. In fact, uncarburetted water gas would not touch it. The mischief is done by the naphtha enrichments composing the olefiant series. These are high solvents of everything bituminous. Gas which leaks from a buried pipe works its way upward until it strikes the binder of the asphalt. This is attacked by the olefiants, and decomposed. The gas, returned to the composition of uncarburetted water gas and inert, so far as asphalt is concerned, works its way in all directions until it finds some avenue of escape.

One of the largest industries in connection with bitumen is the manufacture and application of bitumen damp course and sheeting and the laying of conduits with bitumen. The writer met Mr. Thomas Callender, Chairman of the Board of Directors of Callender's Cable and Construction Co., in London, and was surprised to hear that the company had at that time seven thousand men at work in their large factory at Belvedere and on the work they were constructing.

Mr. George M. Callender called attention to an opinion given by Mr. Allan Greenwell, A. M., I. C. E., who prefaced his views with the statement: "'The art of directing the great sources of power in nature for the use and convenience of man' is the apt definition given by the late Thomas Telford of that species of

SPADINA AVENUE (100 FEET WIDE), TORONTO, CANADA.
Laid with Acme Asphalt by The Warren Asphalt Paving Co.

knowledge which constitutes the profession of a civil engineer, and is perpetuated in the Charter of the Institution of Civil Engineers. In the acquisition of this knowledge the civil engineer has to make himself acquainted with the various physical properties possessed in varying degrees by the different forms of matter."

Mr. Greenwell further states that asphaltic materials are now being largely used in order to render works impervious to water. They possess the advantage of small relative bulk, ease and rapidity in laying, and claim to possess sufficient elasticity in order to accommodate themselves to slight alterations in the shape or condition of structures due to the subsidence, expansion or contraction or other causes.

In considering these materials a distinction must be drawn between:

(a) Pure asphalt or bitumen.

(b) Rock asphalt or bitumen and calcareous rock.

(c) Artificial asphalt, manufactured with coal products.

Artificial asphalt has been introduced to the engineering profession under many forms, but each form in turn has proved to be unreliable, absence of elasticity resulting in fracture and fissuring, being its constant defect. The unfortunate popular lack of knowledge as to the real nature of bitumen, and its essential difference from artificial or so-called tar asphalt has, however frequently permitted the substitution of the latter for the former causing incalculable detriment to the proper appreciation of the pure substance.

Rock asphalt although a natural substance containing pure bitumen, is also wanting in elasticity, and is therefore not adapted for works where imperviousness to water under all circumstances is a sine qua non.

Pure bitumen appears to possess those qualities, including elasticity, which are requisite in a perfect waterproofing material for use in engineering works, and experience of its use under most trying circumstances leads to the conclusion that it may be classed as an absolutely reliable material, for which a great future may be safely predicted.

In Mexico there are nummerous deposits of asphalt principally of the maltha or liquid grade; it has been found in numerous deposits from the Panuco River to the Isthmus of Tehuantepec. While a few hundred tons of this material have been shipped to the United States, the expense of getting it here has been so great

that its use has been abandoned. From this country, also, comes the Chapopota asphalt used for varnishes but generally superseded in use by less expensive asphalts of a similar nature.

In the last report of the U. S. Geological Survey an occurrence of bitumen was reported in Oklahoma about 3 miles southeast of Fort Sill. From recent information received from Captain Farrand Sayre, U. S. Cavalry, then stationed there, the deposit is known as "Tar Spring," a black substance oozes out from the ground which is now believed to be petroleum. A well has been bored near it in the hope of finding mineral oil, and natural gas has geen found. No bituminous limestones or sandstones are known to be in the region.

The latest commercial development of asphalt is the refinery of the United States and Venezuela Co. erected near Maracaibo, where is refined the product of an asphalt lake containing 97 acres area of solid bitumen. This refinery with other improvements cost about $500,000, and large quantities of the refined material have already been brought to this market. Professor Stillman, of the Stevens Institute of Technology gives the analysis of the asphalt as follows:

	Crude.	Refined.
Bitumen	94.13	99.07
Woody fibre, etc.	4.85	0.25
Ash	1.02	0.68
	100.00	100.00

and adds "The Refined Asphalt is of very superior quality." Ralph T. Rokeby, the President of the company, evolved the idea of filling the refined asphalt into bags which has proved a wise innovation, as the saving in cost of the weight of these packages as against the heavy wooden barrels generally used is a great benefit to the purchasers.*

*Author's Note: Owing to troubles with the Venezuelan Government it has been impossible for the last three years to import this material from Maracaibo.

CHAPTER XII.

DEVELOPMENTS OF THE ASPHALT INDUSTRY UP TO 1903.

DEVELOPMENTS of the Asphalt Industry up to 1903 were so ably treated on before the Institution of Civil Engineers in London, by his long tiem friend and coadjutor, William Henry Delano, of the Val de Travers Asphalte Paving Co., that the author has given his paper, "Recent Developments of the Asphalt Industry," verbatim.

"Since 1880, when a paper* by the author on "The Use of Asphalt and Mineral Bitumen in Engineering," was read before a meeting of the Institution, the employment of the material has so largely increased that it may be worth while to take a retrospective view, and a glance into the future of this industry, in which so much British capital is invested, and the development of which gives employment to so many engineers.

"Asphalt is a natural product, and consists of limestone impregnated with pure mineral bitumen. Its ideal composition is 80 per cent. to 90 per cent. of pure carbonate of lime, and 10 per cent. to 20 per cent. of pure mineral bitumen. Bitumen is natural mineral pitch, composed of 85 per cent. of carbon, 12 per cent. of hydrogen and 3 per cent. of oxygen. It is only found pure in the rock which it permeated when in a state of vapor, and under enormous pressure. The recent eruption of Mount Pelée, in Martinique, affords evidence of the great heat and pressure caused by the combustion of bituminous vapors. Mineral bitumen should not be confounded with the residuum of crude petroleum, naphtha, shale, or animal fats, nor, above all, with gas-tars: these contani dyes, which natural bitumen does not. As asphalt and bitumen are

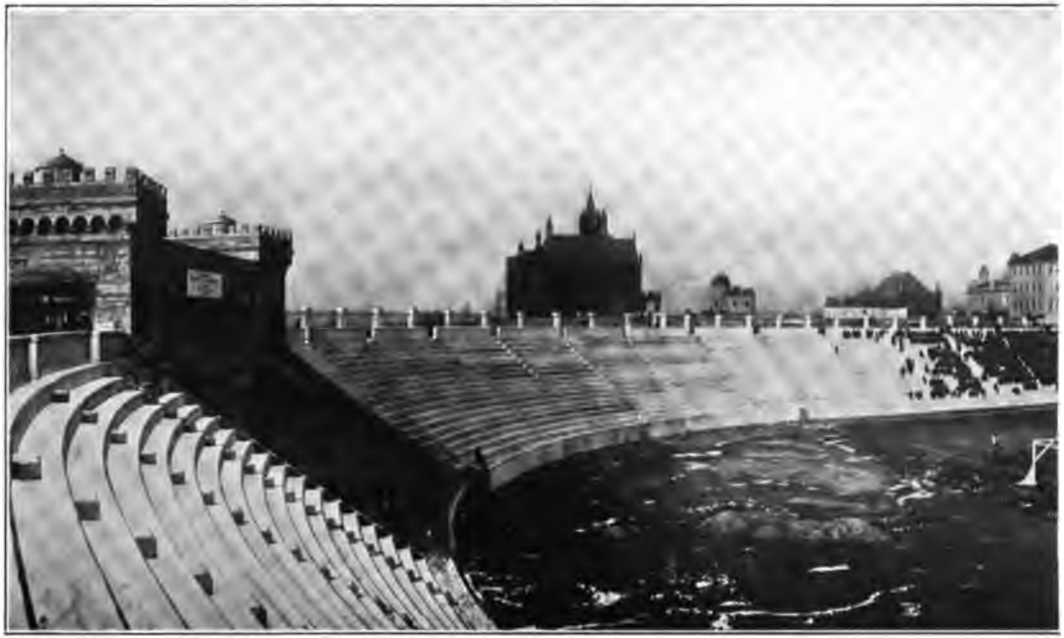
*Read before the Institution of Civil Engineers, London, Eng. Sessions 1902-1903.

natural products, they vary in quality and must be taken as Nature produces them. Thus the limestone in the Sicilian variety of asphalt is of coarse grain; but in Seyssel, Val de Travers and Servas asphalts the grain is fine, so that the specific gravity of Sicilian asphalt is less than that of the other rocks named. The bitumen contained in Seyssel and Sicilian asphalts is solid and tough, whereas that contained in Val de Travers asphalt is oily.

"The author having experienced much trouble due to waves and buckling in roadways of Val de Travers asphalt under heavy traffic and exposure to hot suns, consulted the later Mr. Schützenberger, Professor of Chemistry at the Collège de France, who had made a special study of hydro-carbons. This eminent chemist, after separating the bitumen from the pulverized rock by dissolving it in carbon di-sulphide and filtering the solution, heated the bitumen in vacuo without obtaining any appreciable evaporation; when the heat was increased the bitumen decomposed. This showed that the oil could not be got rid of by heat, and led the author to blend Seyssel with Val de Travers, and subsequently with Servas rock, with satisfactory results. By blending, asphalt powder for roadways can be obtained suitable for tropical or temperate climates.

"The molecules of natural asphalt are held together, not by cohesion, but by bituminous agglutination. Mr. Léon Malo found that the test for asphalt is to heat a small piece on a hot iron plate, when it will fall to pieces. To test its compressibility, a small hydraulic press with appropriate molds, or a tube with a plug and hammer, may be used. Some asphalts, after being subjected to a pressure of 6 tons per square inch, will crumble under pressure of the fingers. The unimpregnated limestone found in an asphalt mine will not crumble on being heated.

"Asphalt mastic is composed of asphalt powder and refined bitumen, mixed mechanically in a boiler under heat. The mixture, after being heated to, say, 400° F., is run into molds, the blocks weighing about 56 pounds. It should contain about 15 per cent. of bitumen, native and added, and will not fall to pieces on being heated, as asphalt rock does, nor will it compress. Mr. Malo has pointed out that in a layer of compressed asphalt the top of the layer is always denser than the bottom, even when the thickness has been reduced by wear to ½ inch. The surface, therefore, always rests on a cushion. To make good mastic, care and experi-



SYRACUSE UNIVERSITY STADIUM PROMENADE.
Surfaced with Magdeburg Rock Asphalt Mastic by The Central City Roofing Company, of Syracuse, N. Y.

ence are required. It must be made of blended rocks, ground very fine, mixed with refined bitumen and thoroughly cooked; it cannot be too pure. For footpaths, grit is added to it, say, 33 per cent. for temperate, and 50 per cent. for tropical climates. Clay, pyrites and vegetable matter are all detrimental, whilst taking up the place of good material. The qualities of asphalt, bitumen, and their product, mastic, are remarkable, and are daily being more and more appreciated in engineering work.

"Asphalt makes noiseless roadways, is impervious to water, and produces no dust or mud; mastic makes footpaths like a carpet, arrests capillarity, is air-, water- and vermin-proof, absorbs vibration and is a non-conductor of electricity. By mixing bitumen with pure silex, a mastic can be made which resists acids.

"The Island of Sicily alone now produces annually 75,000 tons of natural asphalt, sufficient to lay 812,000 square yards of compressed asphalt, 2 inches in thickness; whilst the output of the other mines in Europe (Seyssel, Val de Travers, Chieti in the Abruzzi, Limmer, Vorwohle, Lobsann, Auvergne and Syzrane in Russia) may be estimated at 120,000 tons annually; whereas previously to 1870 the Seyssel and Val de Travers mines were the only ones of repute, and their combined annual output was about 50,000 tons. When in the United States some five years ago, the author noticed that one American Company, managed by a Colonel of Engineers, had an army of 18,000 men employed daily in laying bituminous compounds for roadways in different towns of the Union. Often the process followed was to construct the roads first, and to build the towns afterwards; where money was not available, payments were effected in bonds on land, or even on produce. The author's experience has been acquired chiefly in France, where the asphalt industry originated, and where the special plant and tools, now used everywhere, were invented and elaborated.

"In 1872 the author was called upon to undertake the management of the original Asphalt Company, which had the contract for all the compressed asphalt roadways for the town of Paris. These roadways were then being laid on hydraulic-lime concrete, only 4 inches in thickness—actually the same thickness as for footpaths—and of this ½ inch thickness consisted of a mortar floating, spread upon the concrete after it had been laid, which crumbled under the blows of the rammers used in ramming the

hot asphalt-powder to make the road. On the author's recommendation, Portland-cement concrete was laid, at the company's expense, in the Rue d'Antin, and this work stands to the present day; the old streets, however, were all laid on lime concrete. Some of the engineers of the town of Paris who had the superitnndence of the works declined to have Portland-cement concrete at any cost, and at the end of five years, when the concrete wore out, the company had lost £40,000, owing to the onerous conditions of the maintenance contract, by which they were paid 1 franc per square metre per annum for all repairs, including the relaying of one-tenth of the surface annually and setting the whole in order at the end of the contract. When holes in the asphalt had to be repaired, the crumbling concrete had to be relaid also, but, owing to the exigencies of traffic, it had not sufficient time to set, so that work was carried out under grave difficulties; and in rainy weather, in order to get a dry surface for the hot powder, it was necessary to use bituminous concrete, or at least a layer of liquid asphalt.

"In general, yielding materials like asphalt require a rigid and resisting concrete, and floating is undesirable. Finding how detrimental to the asphalt roads was the greasy mud brought from macadam and stonepitching, the author presented the town of Paris with one hundred india rubber squeegees, and this led to the adoption and manufacture of these tools in France. He also designed a special form of water cart for cleaning asphalt roadways, the sprinkling being effected in front of the horses, sa well as behind them, the French plan of flushing with a fireman's hose and nozzle being impracticable in narrow streets or in windy weather. The extreme gradient for an asphalt roadway is 1 in 30, and the camber between the outside edge of the gutter and the crown of the road should not present gradients of more than 1 in 50.

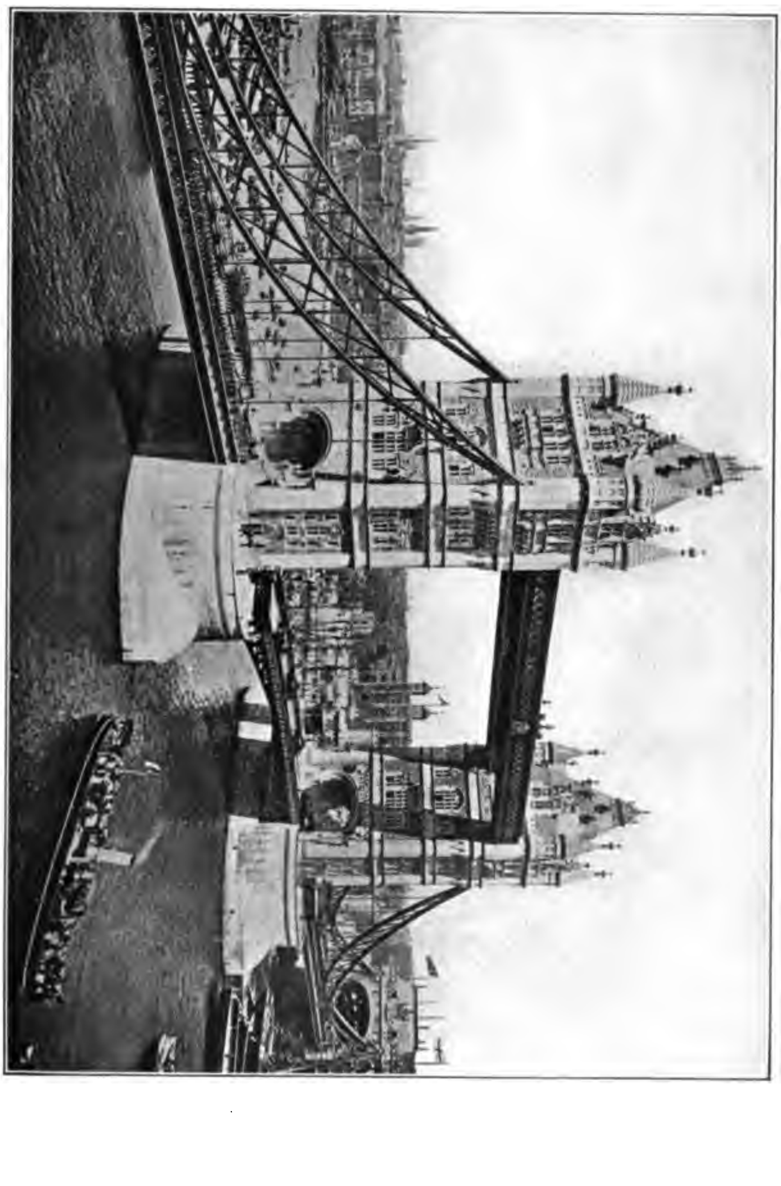
"In 1884 the town of Paris made a 10-years' contract with the author's company, by which they agreed to pay, for a 2-inch layer of compressed asphalt, 14 francs per square metre (9s. 4d. per square yard) and for a 6-inch layer of Portland-cement concrete 5½ francs per square metre (3s. 8d. per square yard), and for maintenance 2 francs per square metre (1s. 4d. per square yard) per annum, with the undertaking that all the streets laid with lime concretes should be relaid with Portland-cement concrete, the town paying for the repairs on those streets apart, until the sub-

stitution should take place. It was in 1884 that Sicilian asphalt was accepted for the first time, the Paris engineers having been commissioned to visit and report on every asphalt mine then known, and it took the place of St. Jean de Marvejols asphalt, being cheaper. A branch of the London Limmer Asphalt Company obtained the contract for about one-third of Paris, but afterwards passed over their contract to a French company, formed by the Neuchatel Company, Limited, which holds the concession for the Val de Travers mines, who had not renewed their concession to the author's company. It is notable that English capital had absorbed the asphalt industry originated in France, and led to its development all over the world.

"The town of Paris allowed the contractor to grind up the pieces of old compressed asphalt from gas trenches and repairs, and to convert it into mastic for the liquid gritted asphalt footpaths; but it would not allow the old gritted mastic from the footpaths to be used again for new works or relayings; this could only be used for small repairs and trenches, and even then only if mixed with an equal quantity of new material. The area of the asphalt mastic footpaths in Paris is about 6,000,000 square yards; this material provides a surface which is less fatiguing to walk on, and much more agreeable to the sensitive human foot, than granite, stone, or hard cement. The town paid 35 centimes per square metre (2.8d. per square yard) per annum for the maintenance of the footpaths, laid 15 millimetres (9/16 inch) in thickness, for all repairs arising from wear and tear, including the re-laying of one-fifteenth part of the entire surface every year, whether wanted or not. The thickness of the layer being 15 millimetres, and the wear of the surface of the surface being estimated at 1 millimetre per annum, it was supposed that at the end of 15 years the whole surface would be re-laid. In practice, howeve, it was found that the narrow streets in the centre of the town wore out in 5, 6, or 10 years, owing to the heavy traffic, whereas those in the suburbs were as good at the end of 15 years as on the day they were laid. Knowing that old mastic, remelted with fresh bitumen (the main ingredient of asphalt), is just as good as, if not better than, new mastic, owing to the second fusion, the author proposed to lay all surfaces 20 millimetres (3/4 inch) thick, instead of 15 millimetres (9/16inch), using a mixture of equal quantities of old and new mastic, already admitted for repairs and trenches, and to suppress the

obligation to re-lay one fifteenth part of the surface annually, only re-laying what was necessary, thus saving annoyance to householders and unnecessary carting, whilst the contractor got rid of materials easily that otherwise he had to sell to suburban corporations, private undertakings, etc. The proposal was agreed to, and this arrangement has been continued ever since, to the general advantage of all concerned. The concrete used with compressed asphalt prepared in this way is composed of washed flint pebbles, river sand, and best Portland cement, gauged 4, 3 and 1. The cement, not more than 2 months old, is first turned over dry, then mixed wet, being sprinkled just enough to hydrate it. No floating is required. A level surface is obtained by using a straight-edge and smoothing the mass with a flat rectangular shovel, filling up any cavities with a little mortar, composed of 3 of sand and 1 of cement, mixed on the spot. By this plan the whole mass sets at the same time, which is absolutely necessary for hot asphalt powder, whereas for wood or cold asphalt slabs this is not necessary. It is well to allow 5 days for setting in summer, or 7 days in winter, and the surface must be dry, otherwise the powder, heated to 300° F., would convert any moisture into steam, which, in passing through the asphalt, would give rise to nodules. For liquid-asphalt footpaths, hydraulic-lime concrete may be used, and a mortar floating, in order to get a true surface with a straight-edge, and to prevent more asphalt being laid than the thickness warrants. A ¾-inch layer weighs 80 lbs. to the square yard.

Perhaps the best method of protecting any work in masonry, or iron vaults, roofs, reservoirs, etc., is by means of two layers of pure asphalt, 2/5 inch in thickness, superposed, the joints of the first layer being covered; a recess can be cut into the masonry and the fillet pressed in. Such a layer will weigh about 68 lbs. per square yard. A damp-course laid in walls of buildings, at a level of about 1 foot above the ground, will stop capillarity and preserve the buildings from the action of water and frost. To keep out damp is as much a necessity of hygiene as good drainage. The Egyptian Sphinx, the Pyramids, and so many tombs and buildings, not to mention more recent Roman buildings in Africa, have survived mainly because the chief elements of decay, water and frost, are absent; if such constructions had been in England, the expansion caused by frost and the contraction caused by thaw would speedily have disintegrated them. In many brick and stone rail-



THE TOWER BRIDGE, LONDON.
Callender's Pure Trinidad Lake Bitumen Sheeting used.

way arches in Paris, water drips through the joints after prolonged rain. The Pont du Jour, a stone viaduct over the Seine at Auteuil, is full of water in rainy weather, and from certain joints water runs out as from a spring. Mr. Barabant, the Manager of the Eastern Railway of France, who, as Ordinary Engineer, and subsequently as Chief Engineer, of the town of Paris, had special opportunities of studying asphalt—having had the Municipal Laboratory under his charge—has had all the bridges and viaducts on the ordinary and strategic lines between Paris and the frontier laid with pure asphalt coating, and has had the platforms of the Paris and Nancy stations laid in compressed asphalt slabs and powder. The Paris, Lyons and Mediterranean, Orleans, Midi, North and West Railway Companies have largely used Seyssel asphalt for platforms, bridges, viaducts, etc.

"It has been abundantly proved that asphalt mastic is unaffected by cold or heat, i. e., expansion and contraction do not alter its qualities. The late Captain Coignet had some of the Seyssel asphalt coating from the bomb-proof casemates of the Donjon of Vincennes taken up, after laying entombed since 1833, and found that no change had taken place in the asphalt. A root of lucerne, 5 to 6 yards in length, had tried in vain to penetrate the layer. Asphalt has the defects of its qualities, for in foggy weather the moisture in the atmosphere will condense on the asphalted surface of the casemates, and must be swabbed off. This is better than letting it soak into an ordinary soil. But, for this reason, in asphalted railway stations, flour, cement and lime must be kept off the ground by wooden frames. The gradual disintegration of walls and floors is sometimes traceable to the ravages of rats and mice; they will nibble through concrete, but they leave asphalt alone. Being a non-fermenting and non-decaying material, it affords no home for insects. A floor laid on joists fixed on liquid asphalt is safe from vermin, and there need not be any appreciable space between the asphalt coating and the upper flooring. In the case of fire, asphalt keeps out the air, and holds water; when the wood-work below it has been burned away, it will fall like a wet blanket on the flames and extinguish them. This quality was proved by the experiments made by the Omnibus and Cab Companies in Paris, with the result that the floors of granaries and silos, wash-houses, stables and mangers are now generally coated with liquid asphalt. It was found by Messrs. Tourtel

Frères, of Tantonville, near Nancy, that whereas gas tar gave a disagreeable flavor to malt, natural asphalt was absolutely neutral; this has led to its adoption for flooring in many breweries and maltings. Slabs of asphalt of various sizes and thicknesses, made made in a hydraulic press, are now manufactured largely and sent to all parts of the world. They are laid on Portland-cement concrete similarly to asphalt power, but are fixed in a wet layer of pure Portland-cement mortar; after being laid, cement grout is poured into the scarcely perceptible joints, and swept off with sawdust when dry. These slabs stand well in streets and courtyards where there is little traffic, and require no costly plant, as does powder; they can be laid on wet concrete, but, as they have attained their ultimate compression, wear begins at once.

"A method of laying asphalt powder cold, by mixing it with petroleum essence and a solution of india-rubber, which softens the bitumen contained in the rock and so facilitates compression, the petroleum afterwards evaporating, has been recently employed in Marseilles, Antibes, Barcelona, Aix-les-Bains, Toulon, Nice and St. Etienne. By this process work can be done in rainy weather.

"Just as plasterers mix cow-hair with their plaster, and as cement is strengthened by iron wire and rods to give it tenacity under strain, so liquid asphalt can be treated for making tanks, pipes, conduits, reservoirs, etc. Asphalt, and india-rubber, of which it is a counterpart, are both hydro-carbons, having the same ingredients. Asphalt has little resisting power in itself, but it can be laid on a hempen sheet or thick paper, to give it more tenacity, as when laid upon a wood flooring. When liquid asphalt is used for the inside lining of a reservoir, vertically, a layer of brick should be laid in front of it as the work proceeds, to keep it up. In Germany, cement tanks for holding molasses are now being replaced by asphalt, which does not crack. Bitumen resists alkalies and acids, so that by mixing it with pure silex in powder, or with pulverized basalt, a mastic or paste can be made which can be applied like ordinary mastic for accumulator-rooms, baths for electrolysis, etc.; numerous special applications of this material have been made for the Electric Traction Company at Paris, Lyons, and elsewhere. It has been found that the large Portland-cement-concrete blocks used in connection with breakwaters and piers to arrest the force of the waves, become disintegrated by the action of the magnesia in the sea-water, as well as by the boring

propensities of numerous marine animals. The blocks may be protected by an application of liquid asphalt, say 9-16 inch thick, upon each side of the cube, carefully jointed at the angles, and the remedy, though expensive, is sure. Asphalt flags are made by running mastic in shallow moulds on a true-planed cast-iron slab; they are laid on a concrete base, the joints being run with a little special mastic, heated in an iron basin and spread with an iron tool. At the works of the Compagnie Générale des Asphaltes de France, the strong-room is made of bituminous concrete, and is absolutely fireproof. Pipes and tubes can be made for the carrying of telegraph, telephone or power-wires. Bitumen resists the corrosive action of acetylene-gas on iron pipes; and in Paris, water-pipes are coated with a layer of mastic before being laid in the ground, thus preventing external corrosion.

"The chief application of asphalt to which the Author desires to direct attention in this Paper, however, is its use as a material for absorbing vibration, either caused by the passage of trains and heavy vehicles, or by percussion, like that of the steam-hammer, and also as a foundation for heavy ordnance in forts. Mr. Malo, at the Seyssel mines, first experimented on these materials, and his lead has been followed up by the Author. The material used may be either bituminous concrete, or asphaltic powder, as used for roadways; the powder, however, must be rammed in successive layers in a suitable case or box, made of steel or wrought iron, to support and maintain it, and the layer, instead of being 2 inches thick, is 8 inches to 1 foot in thickness. Asphalt powder is used chiefly for foundations for steam-hammers, the bed-plate fitting on to the asphaltic mass. There are numerous examples of its use, and no failure has been recorded. In the year 1872 the Author had at work a Carr disintegrator, making 700 revolutions per minute, for grinding rock-asphalt, the axles being supported on stout oak bearings. The vibration transmitted through the soil was such that it was quite impossible to write within 600 feet of the machine. Being threatened with a lawsuit, he resolved to put down bituminous concrete foundations for the bearings, and to surround the pit in which the machine worked by a wall of the same material. When the work was completed, no one could tell in the adjoining workshops and warehouses whether the machine was working or not, and a glass of water placed on the bituminous concrete wall showed no ripples. For 30 years, during which at

least 5,000,000 tons of asphalt have een ground to fine powder, no repairs have been necessary. One of the more notable applications was made by the Orleans Railway in their underground railway between the Place Denfert-Rochereau and the Port Royal, where the line passed by the Paris Observatory. Admiral Mouchez, who was then Chief of the Observatory, feared that his mercury bath for daylight observations would be shaken, and a foundation consisting of 633 cubic yards of bituminous concrete was therefore laid under the rails in 1894. The trains have run over it ever since, and no repairs have been found necessary. In the premises of the famous firm of Moët & Chandon, who keep a stock of 8,000,000 bottles of champagne in the cellars, it was feared that the machinery laid down for the electric lighting of their 8 miles of cellaring, would shake the wine, and in 1888 the author put down 21 cubic yards of bituminous concrete, with a most satisfactory result. In 1892, the machinery being increased, the author laid down an additional 17 cubic yards. In the author's opinion, the vibration on the Central London Railway would be absolutely arrested by laying the rails on a foundation of bituminous concrete. Of course, the train service would have to be stopped, but a great deal might be done in the night at bad places.

"For iron bridges over which, or under which, trains pass, this material is invaluable. Where a Portland-cement concrete will crack like mosaic, this material will stand. The author has proved this in many cases, notably at an iron tubular bridge over the Seine at Elbeuf; at the Pont de l'Aqueduc, in Paris; and at the railway bridge over the Ceinture, or Girdle Railway, at Courcelles. At many forts around the French coast the very heavy pivot-guns are mounted on foundations of bituminous concrete, which absorbs the vibration produced by a heavy discharge. The author has also used a coating of asphalt mastic in the granite embrasures of forts to counteract the splintering caused by the impact of small shells.

"During the Commune of Paris, in 1871, the works of the author's company at the Quai de Valmy were under fire, and bullets which struck a heap of asphalt powder were flattened out. This led to the coating of iron turrets with asphalt. The late General Boulanger, when Minister of War, arranged with the author to build a block of 390 cubic yards of bituminous concrete

WORTHING, ENGLAND.

HOVE, ENGLAND.

SURFACED WITH SEYSSEL ROCK ASPHALT MACADAM.

at the Polygon of Bourges, to test the effect of melinite shell, similar blocks being made of Portland-cement concrete and hydraulic lime concrete. The whole was surrounded by a wall of unmortared stones. Melinite shells, 4 feet 3 inches in length by 1 foot 1¾ inches in diameter, with chrome-steel points, were fired at these masses. The result was that the cement- and lime-concrete blocks were pulverized; the bituminous concrete was not pulverized, but was torn asunder.

"The chief asphalt mine in Europe is the Seyssel mine, the largest in France. It stretches from Seyssel to Bellegarde in the synclinal basin of the Rhône, which flows through the Department Ain on the east, and the Haute Savoie on the west. It is 10 miles in length and a little more than 3 miles in width, and its superficial area is about 20 square miles.

"The bitumen which binds the soft lime oolite in this mine to form asphalt must have impregnated the limestone in a state of vapor, as is proved by the smoky appearance in the unimpregnated rock at Seyssel. The occurrence of bitumen in Trinidad, Venezuela, Cuba, and Mexico, on the surface of the earth, in its viscous state, just as it can be extracted from asphalt rock, would therefore appear to be due to the bituminous vapors having, at some depth, met with some porous rock like sandstone, through which they filtered upwards.

"In Europe, the country that has taken the lead in laying compressed asphalt undoubtedly is Germany. There is more compressed asphalt paving in Berlin than in England and France together, there being about 2½ million square yards, all laid on Portland-cement concrete, 8 inches in thickness. These magnificent roadways are one of the features of Berlin, and give it an aspect of brightness and cleanliness unknown to other European towns. The Germans have studied asphalt synthetically, and have produced sundry imitations. An artificial asphalt, composed of limestone and bitumen, introduced by Professor Dietrich, of Berlin, was laid in König-strasse, Berlin, but was afterwards replaced; a mixture of Vorwohle asphalt and bitumen is used to a considerable extent. These mixtures are, perhaps, cheaper than natural asphalt, since, being made on the spot, the cost of railway carriage from the mines is eliminated; but they are inferior to natural asphalt, and with heavy traffic the surface has to be frequently repaired. German contractors have followed the English

lead, and have bought mines in Chieti in the Abruzzi, in Italy, and in Venezuela.

"In conclusion, the author is of opinion that English municipalities can borrow money so cheaply that it is not worth while to forego the advantages of hygienic streets, in asphalt, liquid and compressed."

Chapter XIII.

ASPHALTS IN 1908.

ABOUT five years have elapsed since the foregoing chapters were published*. During this semi-decade the increase in the asphalt sources of production has grown by leaps and bounds. Their utilization has also found numerous new channels in the latest construction improvements of this twentieth century. Unquestionably the most important development is in the Texas asphalt refineries. In 1905 the author wrote for "Mineral Industry," Vol. 13, published by the Mining and Engineering Journal, as follows:

"In 1903 considerable strides were made towards bringing Texas maltha and asphalts into prominence, and in 1904 the production was certainly more than that of California in 1902. The Texas asphalts are the residuum of heavy asphalt oils, similar in character to the California malthas, but with slightly different chemical properties. These asphalts have not been used for paving without mixture with other asphalts, and have therefore not attracted the attention given to California products. It is said, however, that Texas maltha has very generally taken the place of California maltha as the fluxing material used with the harder asphalts for sheet asphalt pavements throughout the country east of the Mississippi River. This maltha has been extensively used in manufacturing artificial bitumens, and it has been used in conjunction with Cuban hard asphalt, Trinidad manjak, gilsonite and other asphalts requiring large amounts of softening material to give them pliability.

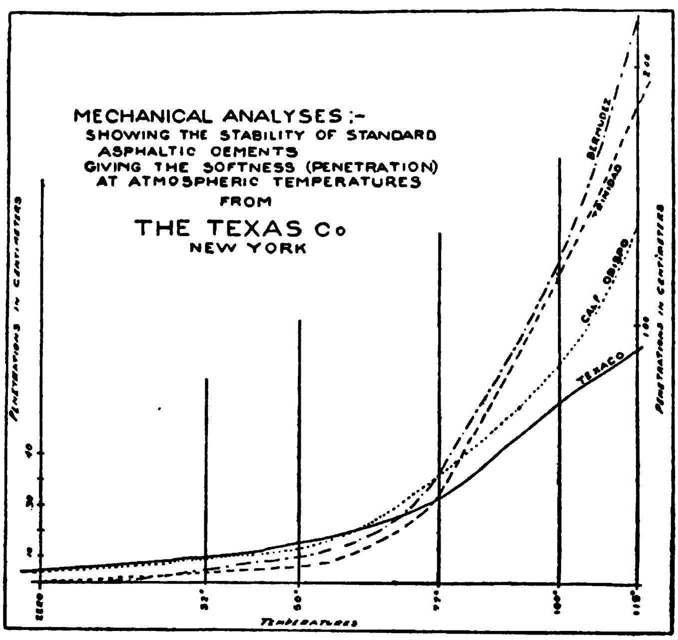
The production in 1904 has been estimated at from 25,000 to 30,000 tons. A large refinery was operated at Marcus Hook, near Philadelphia, but exact statistics of production there and in Texas are not available."

---

*They appeared in a series of twelve monthly issues in the "Architects and Builders Magazine."

The trouble then experienced in obtaining full data on this subject continues to exist, but from the fact that the Gulf Refining Co. produced in 1907 over 25,000 tons one gets the most astonishing fact, that should the production of the Texas Co. and the Sun Co. have been in the same ratio, the result would be about 75,000 tons of material, which, on a basis of 99 per cent. pure bitumen, would equal 150,000 tons of crude Trinidad asphalt, that material losing 30 per cent. in refining and the refined material yielding only about 54 per cent. of bitumen.

The methods of refining appear to be different among the companies named. The "Texaco" for instance, shows in the penetration test the following comparisons with other well-known asphalts:



The refining of Boorman's Noflux asphalt yields a material giving practically the same results in the penetration. This material is sold for fluxing European rock asphalt mastics and for use in Malthalithic sidewalks and roads, as well as in the standard sheet asphalt pavements.

THE FIRST FREE PUBLIC PLUNGE BATH IN NEW YORK CITY ON WEST 60TH STREET.
Waterproofing done by The Sicilian Asphalt Paving Company. Runways laid with Rock Asphalt Mastic from The United Limmer & Vorwohle Rock Asphalte Company, Ltd.

The uses to which these asphalts have been put are varied, and to a great extent, they have been used for blending with hard or glance pitch asphalts for different classes of work, and extensively for water proofing and insulating and in the manufacture of roofing felts and prepared roofings. One of the latest applications of this material seen by the writer was in the laying of the pavement of Springdale Ave., between Roseville Ave. and 13th St., Newark, N. J., where a two and one-half inch asphalt concrete of Texaco asphalt was applied on a 6-inch Portland-cement concrete base with gratifying results.

The Texas liquid asphalts have entered largely in what is termed "blended asphalts," one of which is the Dunderberg asphalt, a blending of Trinidad manjak or glance pitch with liquid Texas, the Dunderberg Asphalt Co. of New York having a plant at Jones' Point, on the Hudson, where the material is refined. The Barber Asphalt Paving Co. also manufacture the "blended asphalts," and other companies refine hard asphalts on similar lines.

Among the best qualities of California asphalt is that refined for the Warren Asphalt Paving Co., known as Acme Asphalt. The specifications read as follows:

"Acme" Asphalt Paving Cement.—The cementing material, or paving cement, shall be prepared from the best quality of pure "Acme" refined asphaltum mixed and thoroughly agitated with "Acme" asphalt flux and unmixed with any of the products of coal tar or inferior bituminous products.

The asphalt must be absolutely unaffected by water and succesuflly withstand the following tests:

(a) Paint a glass slid ewith a very thin film of the asphalt cement.

(b) Make a briquette of sand heated to about 250 degrees Fahrenheit, all of which will pass a No. 20 and none pass a No. 30 screen, mixed with hot asphalt cement in the proportions by weight of one part of melted asphalt to nine parts of sand, and press into a briquette, such as is used for testing hydraulic cement or other convenient mould. Immerse the asphalt-coated glass and the briquette in water at a temperature of 70 degrees to 90 degrees Fahrenheit, so that a part of the asphalt is below and part above the water. Daily renew water lost by evaporation. If under either of these tests the asphalt near or below the surface

of the water turns a brownish color and has a disintegrated appearance, or an odor of decay, it will be rejected.

Trinidad Lake Asphalt will clearly show deterioration by this test within a week, and other inferior asphalts in a somewhat longer time.

Binder Course.—On the concrete foundation prepared and laid as above shall be laid a binder course, which, after compression with a steam roller, shall have a thickness of one (1) inch. The binder course shall be made of crushed stone or gravel, all of which shall be of such size as will pass a screen having one (1) inch openings, which, after heating to about 250 degrees Fahrenheit, shall be mixed with "ACME" asphalt paving cement in such proportions as will thoroughly coat every particle of stone.

Wearing Surface.—The wearing surface shall be composed of,—

"Acme" asphalt cement (pure bitumen) from..	9 to 11 per cent.
Sand	88 to 79 per cent.
Pulverized carbonate of lime..................	3 to 10 per cent.

In order to make the pavement homogeneous, the proportion of asphaltic cement must be varied according to quality and character of the sand. The carbonate of lime may be reduced or omitted entirely when suitable sand can be obtained. The sand and asphaltic cement will be heated separately to about 300 degrees Fahrenheit. The pulverized carbonate of lime shall be mixed with the hot sand in the required proportions, and then mixed with the hot sand in the required proportions, and then mixed with the asphaltic cement at the required temperature, and in the proper proportions, in a suitable apparatus, which will effect a thorough mixture. The pavement mixture, prepared in the manner thus indicated, will be laid on the binder in one coat; it will be brought to the ground in carts or wagons, at a temperature of about 250 degrees Fahrenheit; it will then be carefully spread by means of hot iron rakes on the binder, in such manner as to give a uniform and regular grade, and to such depth that, after having received its ultimate compression, it will have a thickness of one and one-half ($1\frac{1}{2}$) inches or two (2) inches, as the traffic conditions may demand and as the engineer may specify. The surface will then be slightly compressed by light hand or

steam roller, after which a small amount of hydraulic cement will be swept over it, and it will then be thoroughly compressed by a steam roller of at least five (5) tons' weight, the rolling being continued as long as it makes an impression on the surface.

During the past three years the city of Winnipeg has purchased Acme asphalt and has laid 37,000 square yards on its leading thoroughfares.

This city, under the direction of Mayors Andrews and Arbuthnot and City Engineer Col. H. N. Ruttan, bears the important distinction of being the first municipality to organize and successfully carry out the laying of asphalt pavements by the direct purchase of all the materials and employment of labor without the intervention of paving contractors. The results which have been published show that this has been a very great success both in character and economy of construction. It is very evident that the city has done the work in the most economical manner and that it has saved not only the contractor's profit, but the cost of bonds and other expenses of organization, etc., to which a contractor is subjected and which add very materially to the contractor's cost.

The city purchased a complete asphalt paving plant. The work was done under the general supervision of Colonel Ruttan, City Engineer. The asphalt construction of the work has been done during the past three years under the immediate efficient supervision and expert advice of Mr. F. E. Puffer, of Newark, New Jersey, and formerly Superintendent of the Warren-Scharf Asphalt Paving Company.

CHAPTER XIV.

ASPHALT IN BUILDING CONSTRUCTION.*

ASPHALT is a material that has received but little consideration at the hands of engineers and architects. When even in Paris, the city of asphalt, the paper announced during the siege of that city that "If the besieged lacked bread, they were, at least, not likely to lack combustibles, for they could burn the asphalt which was in their streets," it is not surprising that elsewhere the information as to the properties of th ematerial should be of a meagre character. Lately asphalt has been more fully discussed in its relation to street pavements. In this direction I will not trespass upon your time this evening, but will confine myself to its use in the construction of buildings. Asphaltos is an ancient Greek word which passed into the Latin as asphaltum. The English word asphalt is applied to the bituminous limestones or the bituminous pitch which are commonly known as "natural asphalts." From the earliest days we hear of asphalt, and in the book of Genesis we read of its use both in the Tower of Babel and in the construction of the ark. It is said that th ewalls of Babylon were cemented with asphalt, and evidences still exist of its use by the Egyptians. The first treatise on asphalt aws published in 1721, having been written by Eyrini d'Eyrinis, "Professor of Greek, Doctor of Medicine," and treated in a half serious, half humorous manner of its uses for building purposes, claiming it as a panacea for almost every sickness. This curious pamphlet was reproduced in one of the publications of Mr. Leon Malo, C. E., of Paris, whose works on asphalt pavements are the most practical and scientific of any written on the subject. While the claims of the eccentric doctor that its use would stop the gout, cure children's chilblains, etc., appear ridiculous, the sanitary benefits of the introduction of the material are undoubted, and the good effects of inhaling the smoke of the hot material is evi-

*Paper read before the Architectural Students' League of Brooklyn May 14th, 1890, by Mr. T. H. Boorman, of New York.

WEST STREET BUILDING, NEW YORK.
Waterproofing done by The Sicilian Asphalt Paving Company.

denced by the rugged health of the men who are engaged in laying it, and I may also mention that at the time the yellow fever raged in Memphis a few years since, it was proposed to burn asphalt in the streets to prevent contagion and kill the fever germs. In 1834 M. de Puvis, in the "Annales des Mines," gave particulars of the manufacture of asphalt mastic at Pyrimont, and recorded the confidence already felt in that mastic used for footpaths at Lyons. The first asphalt work that I know of being laid in this country was about the year 1838, on the floors of the portico of the old Philadelphia Merchants' Exchange.

Twenty-five or thirty years ago the European asphalts were extensively imported, at a great expense by our Government for use on fortifications in covering the arches over casemates, magazines, vaults and for other similar purposes. Since 1872 they have been imported by asphalt companies and used in buildings of all descriptions.

Rock asphalt is a lime ore impregnated naturally by a geological phenomenon, still but imperfectly explanied, with bitumen in the proportion of 8 to 17 for 100. It is found in strata like coal. The principal mines are the Limmer, near Hanover, Germany, the Neuchatel in Switzerland, and the Seyssel in France. For street work, the mines at Ragusa, Sicily, produce a rock, rich in bitumen, which has been used in New York and other American cities with great success. On the coast of California, near Santa Barbara, and also in certain portions of Kentucky, Colorado, Utah and New Mexico, are found large beds of sandstone containing from 15 per cent. to 20 per cent. of bitumen. Recently this material has been used for paving in cities on the Pacific coast.

For use in buildings the natural rock is manufactured into what is known as asphalt mastic in the following manner:

The rock, after being reduced to powder, is placed in cylindrical kettles, in which about 8 per cent. of Trinidad asphalt has previously been placed and melted. The mass is stirred by revolving arms and agitators, at a temperature of about 350° F., for about five hours. It is thus thoroughly "cooked," and is then run out of the kettles into moulds, where it cools in the form of cakes or blocks, weighing from 50 to 60 pounds each. These are stamped wit hthe brands of th emines and imported into this country. The mastic so prepared shows an analysis, according to a report on Limmer blocks, manufactured by "The United

Limmer & Vorwohle Rock Asphalt Co., Ltd.," prepared for the Department of Public Works, Philadelphia, by Dr. Charles M. Cresson, as follows:

Bitumen	14.30	per cent.
Carbonate of lime	85.20	"
Silica, alumina and oxide of iron	.50	"
	100.00	"

To use it for walks or floors the material is again heated in suitable kettles in the following proportions:

Mastic blocks (broken)	60	lbs.
Trinidad asphalt	4	"
Fine gravel and sand	36	"
	100	"

This is "cooked" for about five hours at a temperature of about 400° F., great care being taken constantly to stir the mixture. It is then taken out of the kettle by th ebucketful and poured on the foundation prepared, its consistency being such that it will flow very slowly. It is then spread by means of wooden trowels, and compressed and smoothed. by rubbing, as in plastering.

Sidewalks so laid on concrete foundations have given great satisfaction in Paris, and are almost exclusively used throughout that city. Their superficial area is nearly 5,000,000 square yards, and their length probably exceeds 1,000 miles.

In London, Berlin and Hanover, also, sidewalks of this material are used very extensively—in the latter city almost entirely.

Having thus briefly described the preparation of asphalt mastic, I will now speak of its uses. From the cellar to the roof, asphalt has been used where the requirements have been water and fireproof floors. Its principal merits are its utter imperviousness to water or damp, and its elasticity, whereby cracking, especially from the influence of frost, is prevented. Also from a sanitary point of view the advantages of asphalt are incontestable, for it possesses great antiseptic properties, and owing to its having no joints it is impossible for particle of animal or vegetable matter to lodge in crevices and putrefy. It greatly promotes cleanliness, as it can be easily washed, and for this reason is invaluable in hospitals, breweries, stables, etc.

Asphalt first appears in your specifications as under the item of "Damp Course." It is advisable to lay throughout the walls on the grade of the cellar floor half an inch of asphalt, with a lap of about two inches on the inside, so allowing a connection with the asphalt finish of the cellar floor and hermetically sealing the house from damp, noxious gases and vermin.*

In residences you will probably consider you have done your duty by asphalt if you have thus specified for your damp course and cellar floor, in the latter by the way, three-fourths of an inch of asphalt on three inches of hydraulic cement concrete will serve the desired purpose of a durable damp-proof floor.

The yards of city residences are now frequently laid with asphalt, the material being peculiarly adapted to the roller-skates and tricycles of the younger members of a family.

From a building then, in which only one floor, the cellar, is required to be of asphalt, let us consider where every floor and the roof can be of this material; in printing houses, lithographing establishments, breweries, sugar refineries and slaughter houses, you will often find this material used throughout. This year, however, sees a novelty in construction with asphalt. Theophilus P. Chandler, Jr., architect, of Philadelphia, is using rock asphalt on every floor of a large apartment house; the carpets will lay on the asphalt being fastened down to narrow strips of wood set against the partitions when the asphalt is laid. Now, I fancy I hear you say, "Well, asphalt is not pleasant in appearance." Why, gentlemen, the Mayor's private office in the great City Buildings of Philadelphia, the greatest municipal edifice in the country, is laid with asphalt with a border of colored tiles.

Your association I am especially pleased to address tonight, for the reason that I find you wish to listen to practical papers; while so many of you are favorably known as artists with your pencils, you still are disposed to look thoroughly into the more prosaic details of your profession.

The "House Beautiful" must also be the "Home Healthy," and while the people delight in the beauties of architecture evolved from your pencils, they also wish to know that light, heat,

*In connection with this use of asphalt mastic I was informed recently by Mr. J. T. Brumshagen, of Baltimore, that in 1860 the building laws of German cities at that time insisted on a damp-proof course in every building and would allow of the use of nothing but rock asphalt for that purpose.

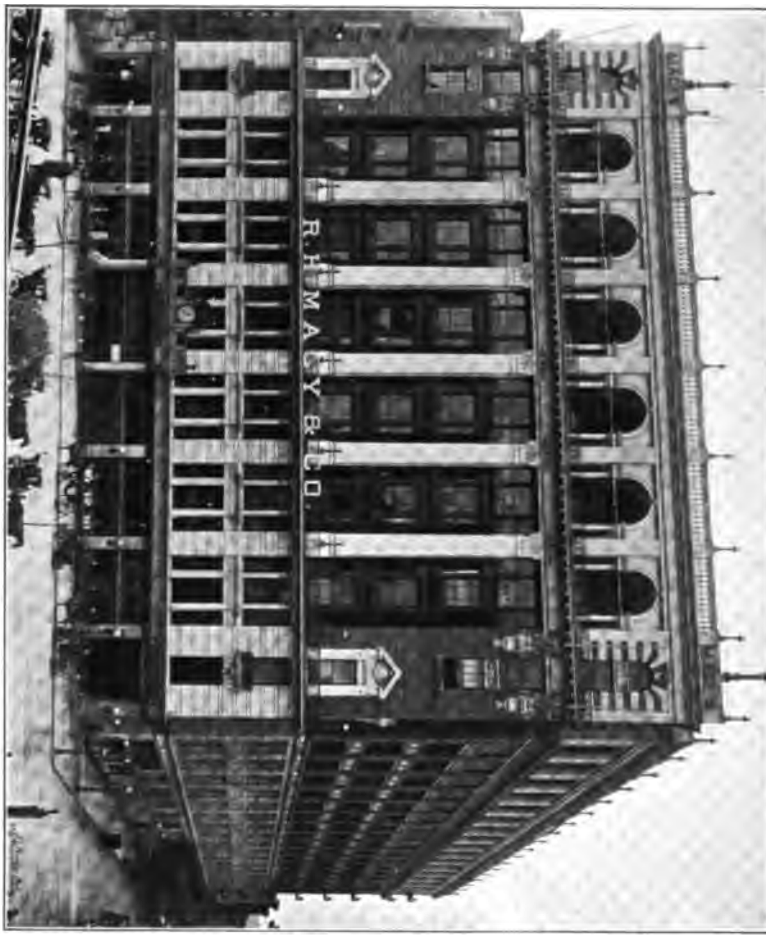
ventilation and sanitation have not been neglected in your plans. This you realize, and in this is your strength.

These remarks are intended to obtain your indulgence, while I venture to make a few suggestions as to methods of drawing specifications for asphalt work gleaned during eighteen years of study and prosecuting such work, including two years' experience as asphalt expert for the Department of Public Works and for the Department of Public Parks of New York city.

For sidewalks and courtyards I would recommend one inch of rock asphalt on four inches of Portland cement concrete, made with the usual proportions of cement, stone and sand. For cellar floors and floors not subjected to much wear three-fourths of an inch of Limmer or other standard brand of mastic will suffice. For floors of breweries, stables, slaughter houses, sugar refineries, one inch is requisite. For ordinary hospital floors three-fourths of an inch thickness will suffice. For the roofs of fireproof buildings on the top of concrete I would recommend an inch and a quarter of rock asphalt, in two coats, laid on three thicknesses of felt paper, cemented with Trinidad asphalt cement or bitumen.

This bitumen is refined Trinidad asphalt which, after a treatment with petroleum residuum, forms an asphaltic cement which can be used with good effect for the coating of walls where they come in contact with the earth. I have seen specifications for the coating of walls with rock asphalt, but the weight of that material is a drawback to its application vertically, and for this purpose and for covering vaults and arches the Trinidad asphalt can be advantageously used. In cases where expense is no object I would say that the rock asphalt can be used vertically, but the work is expensive and tedious. I must not omit to call your attention to asphaltic masonry for engine beds.

Of the use of asphalt in foundations, two very interesting examples are given by W. H. Delano, in a paper read before the English Institute of Civil Engineers in 1880. One was the foundation of a rock-disintegrator, running at a high rate of speed. It was first built upon a foundation of ordinary concrete. On the opposite side of the street was an establishment for painting on glass and china, where fine grades of work were required. The vibrations from the disintegrator were so great that the business of the glass painter was rendered impossible. He threatened suit for heavy damages, whereupon the foundations of the disinte-



R. H. MACY & COMPANY BUILDING, NEW YORK.
Balconies laid with European Rock Asphalt by The Germania Roofing Company, New York.

grator were removed and rebuilt in asphalt concrete. The result was entirely successful, the vibrations becoming imperceptible. The second case was the foundation of a large trip-hammer, weighing forty-five tons, which was erected at the Paris Exposition of 1867. In order to reduce the concussion, this was built in asphalt concrete, and with entire success. At the close of the Exposition, the concrete was so tough that it was found impossible to make an impression on it with a pick or chisel. As blasting was not permitted, the foundation had to be left in position, and it may be still there.

In these cases the concrete was made from rock asphalt mastic. The proportions were 60 per cent. of broken stone and 40 of gritted asphalt mastic. It was tamped between wooden frames, secured by iron cross-bolts, and these bolts were left in the material.

In closing I would impress on you that the use of asphalt has been militated against not only by the lack of general knowledge of the material but by the failure of coal tar products which, under the name of "asphaltic cement," have led the public to condemn the legitimate article. As you do not expect to find the golden balls of the pawnbroker to be gold, neither must you expect to have natural rock asphalt used in your buildings if you specify for "asphaltic cement."

Chapter XV.

DUSTLESS ROADS.

WHEN in England in 1904 the writer became interested in the laying of dust on macadam roads, and found in Newark, Nottingham, the application of "Westrumite."

This is a patented chemical preparation used in the making of roads and for laying the dust in roads, streets and open spaces, and is composed of oily substances rendered oluble in water by certain patented chemical and mechanical processes.

Until the advent of "Westrumite" there were said to be only three agents which could lay any claim to consideration as possible dust-layers, although none of them offered a true solution of the dust problem. These were water, tar and crude oil.

Since then the author has investigated other temporary applications, for relief from the disastrous effects of dust which, since the advent of the automobile, as a regular conveyance and not a luxury, has proved a menace to the health as well as the comfort of the residents and pedestrians on our macadam roads.

There are many temporary allayments which might be mentioned, but in all of which asphalt or liquid asphalt have little or no part, and so they are not considered in this book.

In the year book of the Department of Agriculture for 1902, Col. James W. Abbott, then special agent, Rocky Mountain and Pacific Coast Division, Office of Public Road Inquiries, wrote that public attention was first called to the utility of crude petroleum oil in road betterment through experiments made by the county of Los Angeles in California in 1898, where six miles of road were oiled in that year under the direction of the supervisors. The sole purpose of this work was to lay the dust, which, churned beneath the wheels of yearly increasing travel during the

long dry seasons in that region, had become a most serious nuisance.

The following year this mileage was a little more than doubled in that county, and other counties in California also began experiments along the same line.

From the very first the results obtained were so astonishingly successful that the practice rapidly increased. It spread through every county in Southern California, and then began to work north. Since then it has extended from near the Mexican line, on the south, to Durham, in Butte County, on the north, a stretch covering sections of quite widely differing climatic conditions, with an aggregate of about 750 miles of county roads and city streets oiled for one or more years. Oil has been used on the principal driveways of Golden Gate Park, San Francisco. The mountain stage road into the Yosemite National Park has been oiled for a distance of 30 miles, from its initial terminus at Raymond to eight miles above Wawona. In California it has long passed the experimental stage.

In the California asphalts the asphaltene and petrolene are found combined in very variable proportions. In the petroleums which contain them the combinations of all the hydrocarbons differ, not only in the same immediate oil field, but in the separate strata and even in the same stratum.

The very heaviest of the oils have almost the specific gravity of water, while a naphtha may be 75° B., or even lighter.

From the very beginning of the use of crude oil for roads in California it seems to have been understood that it was the asphalt in the oil which acted as the binder, and consequently they have always sought very heavy oils for that purpose. It might naturally be supposed that the heavier the oil the greater the percentage of asphalt. While this is approximately true, it does not necessarily follow. A crude oil is a complex mixture of light and heavy hydrocarbons, and its resultant gravity depends upon the amount of each kind which it contains.

Table VII. on the next page was compiled from the notes of eleven analyses of crude oils made in California by D. B. W. Alexander, now the Denver chemist of the Colorado Paving Company. The original determinations covered many other data, but in the table only the degrees Baumé and the percentage of asphalt are shown:

All of these oils doubtless contained a small amount of mineral matter which affected the specific gravity and disturbed the relation between it and the asphalt contained.

TABLE VII.
ANALYSES OF CRUDE OILS.

°B.	Per cent. asphalt.	°B.	Per cent. asphalt.
10.4	64.1	15.7	39.9
12.2	45	19	28
13	61	19.3	32.8
13.75	59	23	25.4
15.4	32.1	23	43
15.5	50.2		

The above table shows that in selecting a petroleum for road purposes the specific gravity alone is not a sure guide. It also shows that the California practice of selecting a noil of 12° B. to 14° B. can be depended upon for good results.

Mr. L. B. De Camp, of San Francisco, suggests the following as a crude test used by him; it is probably closer than the Baumé measurement:

Pour a definite amount of crude petroleum into a graduated glass and add an equal amount of refined petroleum. Stir thoroughly together and add to the mixture 2 per cent. of commercial sulphuric acid. Again stir sthoroughly and the asphalt will precipitate to the bottom. The percentage which it represents of the original amount of oil can be measured by the graduations on the glass.

In California, where the aim is to always use an oil containing as much asphalt as possible, the amount of oil required for a 16-foot roadway varies between 250 and 400 barrels of 42 gallons each to the mile. This depends upon the thickness of the oil crust made, the porosity of the material, and the percentage of asphalt in the oil.

The quicker this oil crust is made the better. If two applications are made to a porous material and the oil properly stirred in each time, the crust will be finished. If the hard material is a clay, it should have at least two treatments. One will be sufficient for macadam. A dusty clay will require some gravel added for the first application. On the second application the crust which has begun to form should not be disturbed, but after all the oil

THE HOTEL KNICKERBOCKER, NEW YORK.
Waterproofing by The Union Construction & Waterproofing Company of New York.

sinks in that will a layer of sand should be sprinkled on top. In this oiled crust the bottom will be made from the clay dust and the top mostly fro mthe added sand, while the middle will be a mixture of the two.

In the first experiments a part of the oil was generally put on the first year, and the crust was completed the second or third year. The first year the thin crust was often broken through and a hole was left in the road.

After the oiled crust has once been properly formed all the oil required will not exceed 25 barrels to the mile for repairs in each subsequent year.

During the spring and summer of 1905 the Office of Public Roads cooperated with Mr. Sam C. Lancaster, city engineer of Jackson, Tenn., and chief engineer of the Madison County Good Roads Commission, in making a series of careful experiments at Jackson, Tenn. Tests were made of the utility of crude Texas oil and several grades of its residue when applied to earth and macadam roads.

Seven tank cars of oil, given by some Texas and Louisiana companies, were used at Jackson. It varied in quality from a light, crude oil to a heavy, viscous residue from the refineries. Over seven miles of country road and several city streets were treated.

At first, some of the lighter crude oils were applied with the same tank wagon that was used for the tar. Hose and brooms were used to spread the oil, and practically the same process was followed as with the tar. The oil soaked into the macadam very quickly and left on coating on top. It caused the light covering of sand which was applied to pack down and gave the road a dark color.

It was soon noticed that the preliminary sweeping was unnecessary, as the roads were practically free from dust and oil would penetrate the surface. The removal of detritus was a loss to the road, which had to be replaced by sand to prevent excessive wear on the stone. It was later found that it was much cheaper to use an ordinary street sprinkler than the tank wagon, and in this case spreading the oil with brooms was unnecessary.

The crude oil was used cold, and the cost of applying it by the different methods used is given below.

On a city street 8,266 square yards were treated at the rate

of 0.48 of a gallon of oil per square yard with the use of the tank wagon and hose. The cost of labor per square yards was as follows:

Sweeping street	$0.0011
Filling tank and hauling.........	.0008
Oiling street	.0024
Spreading sand	.0014
Total	.0057

On a country road 2,000 gallons were spread, covering 5,206 square yards, at a rate of 0.38 of a gallon per square yard. The average haul was one mile. Only the manure was removed before oiling. The cost of labor averaged $0.0033 per square yard.

It took nine men thirty minutes to spread 500 gallons, or one tank load, and the 18-foot road was covered at the rate of 1,860 feet per hour. It took twenty-eight minutes to fill the tank car with oil. With an ordinary street sprinkler, one man and team spread one load of 600 gallons of oil in fifteen minutes. The sprinkler thus spread 600 gallons in one-half the time that it took nine men, with the tank wagon, to spread 500 gallons.

The heavy residual oils were so thick when cold that they would not run through a 2-inch fire hose attached to the rear of the tank wagon, and it was necessary to pump the oil upon the road. The pump with which the tank was charged was used for this operation. Only one tank wagon (500 gallons) of the heavy oil was applied cold. It formed a thick, sticky mass on the top of the road that rolled about under pressure and seemed to have an unlimited capacity for absorbing the sand which was spread upon it. The street had to be cleared of the greater part of this mass of oil and sand within a short time.

After this experience the oil was heated in the car by steam, and better results followed. It still ran slowly through the hose and nozzle, and it was found cheaper to take off the hose and allow the oil to flow from the outlet of the tank directly upon the road, where the men swept it over the surface with brooms. An air pump was tried, to increase the floflw of the tank by pressure, but the tank was not tight enough to prevent the escape of air, and this experiment was unsuccessful.

Twenty-four hours after the application of the residual oil it

was covered with sand or limestone screenings, and in four days it was firm enough to bear traffic without showing any wheel tracks. It shed the water well in a violent rain storm.

The following was the cost per square yard of putting residual oil on city streets with the use of the tank wagon. Approximately 0.71 of a gallon of oil was used per square yard.

Sweeping street	$0.0010
Heating, loading and hauling....	.0017
Oiling street	.0029
Spreading sand	.0022
Total	.0078

Excellent results can be secured by the use of this heavy residual oil if it can be applied to the surface of the road at a temperature approaching the boiling point.

The medium grade of oil, which was tried next, is classed by the refiners as "steamer oil." It wa sheavy enough to leave a slight coating on the surface, which made a very compact covering with the dust of the road. Only the heavy matter was removed from the surface of the road before applying the oil. It was heated by steam in the car, but was not hot when it reached the road. It was not safe to build a fire in the tank wagon, and the best road surface was obtained where the oil was at the highest temperature. Some method of heating the oil safely on the road would greatly improve the results. This could be accomplished with a steam straction engine having steam coils connected with the tank, the engine hauling and heating the tank while spreading the oil. Most of this oil was applied with the street sprinkler, and it sprayed readily when hot.

In applying the greater part of the oil on the country roads the following men and equipment were used: A foreman at $2 per day; 6 laborers at $1.25 per day for working on the road and pumping oil at the car; 1 tank wagon and 1 street sprinkler at $3 each per day; 2 firemen at $1.50 per day, and 1 ton of coal. This force spread in one day 3 tank wagons of 1,500 gallons and 3 sprinkler tank loads of 1,800 gallons, making a total of 3,300 gallons.

No sweeping was done on the country roads except to remove manure and to spread the oil where it was inclined to

puddle. No sand or other material was applied to the road after oiling.

More than seven months have now elapsed since the work was done. The light crude oil has produced little if any permanent results. Te roads where it was applied are but slightly changed, and some dust arises on them from traffic. The only apparent result is a slightly darker collore on the "shoulders" of the road, and but little difference can be noticed between this and other sections of the road which were not treated. This oil was too volatile for the purpose, and where it has to be shipped for any distance does not justify the expense of using it.

The medium "steamer oil" fro mTexas has given good results. There is a thin surface coat of dust packed down that protects the stone from the grind and pounding of traffic. This effect is very noticeable in driving over it. The harsh grinding noise of the wheels, which is pronounced on the novaculite surface, disappears at once, and there is decided relief in driving upon it. It is practically noiseless. This coating is perhaps one-eighth of an inch thick, and is not a concrete, but compacted dust, which is made to cohere by the oil with which it is saturated. This road does not wash or "pick up," and the wear on the rock is much decreased.

A good macadam road forms a wearing coat of fine material, which is ncessary to its existence. If this coat is removed, another is formed and the life of the road is gauged by the rapidity with which the detritus is removed from the surface. The more rapidly it is removed the shorter will be the life of the road. The important result of applying the "steamer oil" was that the wearing cost was fixed and held to the surface, consequently the life of the road will be much greater. Of course some of it has blown and washed away, but it is perhaps safe to say that the loss is decreased by at least 75 per cent.

The best results were obtained with the heavier oils when the oil was hot. The road treated with the heaviest oil is entirely dustless. Teams passing from the bare macadam upon the oiled road show this, for the cloud of dust behind a wagon dissapears at once, and the oiled roads can be cleaned or swept as well as the tarred roads. There is but little noise even from the horses' hoofs.

Another experiment was tried of treating an ordinary earth

SPRINGDALE AVENUE, NEWARK, N. J., FROM ROSEVILLE AVENUE TO CITY LINE.
Laid with Texaco Asphalt Concrete by The Texas Company.

road with the heavy oil after it had been shaped and graded. The soil was composed largely of sand and the oil was harrowed into it and the road rolled. This piece of road has become fairly smooth and firm enough to bear traffic. It is not hard like macadam and has small wheel marks. It is about as good as the usual earth road where the soil packs well in fair weather. It is an improvement on the old road, as the sandy soil was cut into ruts, but it can hardly be recommended for use where the oil has to be shipped a great distance and is high in price.

The experiments outlined above were in the main successful.

Another series of experiments was conducted in 1907 by the Office of Public Roads at Bowling Green, Ky. The materials used were Kentucky rock asphalt tested for its fitness as a binder in macadam construction, crude Kentucky oil, and a special preparation of residuum oils, the last two of which were used as dust preventives. This work was done in cooperation with the authorities of Warren County and lay just beyond the city limits of Bowling Green. The location of each section of experimental work is given in connection with its description.

The rock asphalt used in this experiment is a natural product formed in the Chester group of subcarboniferous rocks over a course extending through Breckinridge, Grayson, Edmonson, Logan, and Warren counties in Kentucky, marking the edge of the coal fields lying in the wesetrn part of that State. It is fine-grained sandstone which in the past has been impregnated with mineral pitch or bitumen, the latter averaging from 6 to 8 per cent. with a maximum of 12 per cent. Both appearance and impregnation are irregular, for it is generally found in pockets rather than in distinct continuous veins, and the distribution of the bitumen over the pocket ranges from a mere trace to saturation.

The quarrying and first crushing of rock asphalt are not unlike that of other rock intended for macadam or concrete work. After having been broken into pieces to pass through a 2-inch ring, it is conducted to a series of roll crushers, consisting of parallel steel cylinders. The bitumen in the rock gives sufficient adehsion to carry the material through the rolls, once it has been forced against them. The finished product after crushing is a mass of individual grains of sand, each thoroughly coated with a film of mineral pitch sujciently glutinous to cause it to adhere to surrounding grains and to pack very firmly if subjected to pres-

sure. If chilled when compacted, a lump becomes very hard and tough; if warmed in the hand, the bitumen becomes soft and semi-fluid and the individual grains of sand fall from the mass of their own weight. When freshly crushed it is of rich dark brown color with a slight lustre which gradually disappears as the bitumen hardens and dries.

The test was made on what is known as Cemetery pike, running east from the city limits of Bowling Green. It is the main thoroughfare leading from the southern and eastern parts of Warren County to Bowling Green, the county seat, and, besides being the route for heavy rural traffic, it passes extensive gravel beds and timber lands from which heavy loads are being constantly taken on narrow tires.

The form of construction origianlly adopted was a 20-foot Telford road. When this surface had been worn away under traffic and the foundation exposed it was repaired and brought to grade with a sharp gravel containing about 20 per cent. of sand and clay. This bed of gravel was about 8 inches thick, compacted. Previously to the experiments it was loosened to a depth of four inches by means of a spiked roller and a heavy harrow, and was shoveled out by hand. The subgrade was then made to conform to the crown of the roadway, which was planned to be 4½ inches in 9 feet, or an average of one-half inch per foot. The gravel removed in shaping the subgrade was used for repairs on the roadway beyond the work.

After thoroughly compacting the subgrade with a roller the wearing course of stone was laid. It consisted of limestone crushed to range from 1 inch to 1½ inches in largest dimension and was spread to a uniform depth of 4 inches. This course was then rolled once to turn down the sharp edges of the stone and form a smooth, even surface. No further attempt was made to reduce the voids in the stone by compacting it, as these were to be filled with the rock asphalt. This material was then thrown on with shovels from wagons and dumping boards along one side of the road. It was spread to a depth of 1½ inches, care being taken to break all lumps and to work all the asphalt rock possible into the interstices of the stone without disturbing the latter.

As the work progressed the roller was kept moving back and forth parallel to the axis of the roadway and was worked from the outer edge to the crown as in ordinary macadam construc-

tion. To prevent the adhesion of the bitumen to the wheels of the roller a light coating of natural cement was dusted over the rock asphalt, but it was soon found that in moving the roller off the work at the end of each rolling enough dust collected on the wheels to prevent adhesion and no more cement was used. The stone had not been thoroughly compacted before applying the asphalt, and for this reason a very perceptible wave in the surface preceded the roller, causing the asphalt to crack until after the fourth or fifth rolling. At this stage most of the coating had been forced into the voids of the stone, as was found by cutting into the surface, and very little decrease in its thickness was detected after the rock had come to a firm bearing. In this manner a section 385 feet long and 18 feet wide was paved.

The behavior of the rock asphalt varied according to temperature. During early morning, when both asphalt and rock were cold, it worked into hard, rounded lumps, which were broken with difficulty with the rakes. The location of such lumps was plainly visible after repeated rolling, but they disappeared completely after being subjected to the heat of the sun. As the day grew warmer the material spread smoothly and compacted evenly and uniformly. A light but cold rain, with temperature of 65° F., impeded work for several hours. After a temperature of from 70° to 75° F. was reached work progressed well and good results were obtained immediately. The temperature of the days during the period covered by the work was uniform, excepting at the time of the cold rain mentioned above, with a maximum temperature ranging from 94° to 97° F. during the heat of the day. The inadvisability of working the material when chilled and damp was apparent, for that portion of the road laid at a temperature of 65° F. failed to become hard and firm for several hours after subsequent applications had compacted satisfactorily.

One difficulty met in this work was caused by the necessity for having one-half of the roadway open to traffic, while the other half was under construction. In order to avoid a break or distinct line between the parts, the inner edge of the asphalt was rolled lightly, so that when the other half of the work was laid the loose particles would unite without difficulty. As a result of this precaution an unbroken surface along the middle of the roadway was secured. The ready cohesion of the particles was further shown

when, after an accident, it was necessary to repair a portion which had been opened to traffic for three days. The asphalt and stone were removed over an area of 4 square feet, the stone replaced and tamped by hand, and a new coating of asphalt applied and rolled. After two days no evidence of damage or repair remained visible.

As soon as one-half of the roadway had been surfaced and properly rolled it was opened to traffic in the hope that the asphalt would be further worked into the voids of the stone by the action of wheels and hoofs. At first the coating rutted badly under the weight of the heavy loads of gravel and logs to which it was subjected and the smooth surface given by the roller was seriously cut by hoofs. This effect decreased visibly after three or four days; at the end of a week no trace remained of the deepest ruts and the surface had become smooth and compact. It then presented an appearance not unlike that of an asphalt pavement which has been open to traffic for some time. Close inspection, however, showed the presence of a slight excess of bitumen which held a thin film of dust and fine sand closely and caused it to become incorporated into the surface under traffic. With the passing of time this excess of bitumen disappeared and at the end of four months very little was noticeable.

The conditions necessary to satisfactory results from the use of rock asphalt in this form as a binder in macadam road construction are: That the broken stone of the wearing course be clean and dry to facilitate adhesion of the bitumen and of fairly uniform size and uncompacted to give a large percentage of voids; that the stone be spread evenly and true to grade; that the temperature of the atmosphere be sufficiently high to cause the bitumen to soften and allow the grains to glide over each other readily; that the asphalt be thoroughly raked into the voids of the stone without disturbing the latter.

The simplest method of rolling rock asphalt is to have the roller move forward as far as the work permits, returning with but little lateral change of course. Any great change in the course of the roller accompanied by rapid guiding movement of the trunnion roll causes the loose asphalt to slough over the stone surface and tends to make it adhere to the trunnion roll. For similar reasons sudden starting, stopping, and reversing are to be avoided until the material has been thoroughly compacted. If

ANNEX TO HIGH SCHOOL, YONKERS, N. Y.
Sicilian Rock Asphalt Flooring in basement, sidewalks and yards.
Laid by J. E. Pawson & Company, Yonkers, N. Y.

the roller is driven upon newly spread material a distance less than its wheel base, at the same time working from the outside to the crown of the road, the drive rolls may always be kept upon partially compacted material. In this manner the rolling may be kept abreast of the spreading, little damage being done in case of rain or sudden cold, and any defects in the work will become apparent as the work progresses.

The stone, labor, teams, and roller were furnished by the county authorities. Labor ranged from $1.20 to $1.25 and teams cost $3 per day of ten hours. The roller was loaned to the county for this work and the cost of operating it was $2.50 per day for the engineer plus the cost of fuel. The water for the roller was taken free of charge from the city mains, but as a team was kept constantly to supply water and coal to the roller this amount is charged in the item of rolling. About 65 cubic yards of gravel was removed in shaping the subgrade and used to repair the gravel surface beyond the point where the work stopped. The cost of loading and hauling this material is charged against the asphalt work, while the spreading, rolling, and sprinkling of the gravel is charged against repair work in the preparation of the roadway to receive a treatment of oil. This item is referred to again in the discussion of the cost of experiments in the use of oil as a dust preventive. The unit cost of rolling is large in proportion to the actual cost of the roller to the county, by reason of the short length of road surfaced. As a consequence the roller was frequently idle, though under steam.

Two factors lent themselves to increasing the cost of spreading the asphalt: The inexperience of the laborers in working the material, and the long haul to which it was subjected. The former would have been materially reduced after a few days, but the latter was unavoidable and resulted in packing the rock asphalt so firmly that it required great additional labor afterwards to break the lumps. The stone was delivered on the roadway at $1.20 per cubic yard and was spread 4 inches thick uncompacted, making the cost per square yard delivered 13 cents. The rock asphalt was donated, but is charged in the following table at its market price of $5 per ton f. o. b. cars at Bowling Green, and the cost of loading and hauling it is included in its unit cost delivered on the work. It was spread about 1½ inches thick, or at a rate of 24.5 square yards per ton.

The following table contains an itemized statement of the cost of the various processes of the work:

TABLE VIII.

COST DATA OF ROCK ASPHALT EXPERIMENT.

Item.	Cost per square yard. Cents.	Total cost. Dollars.	Percentage of total. Per cent.
Shaping subgrade	5.66	43.60	11.8
Stone on work	13.71	105.60	28.8
Spreading stone	.78	5.97	1.7
Rolling stone	.09	.67	.3
Asphalt on work	23.77	183.10	50.0
Spreading asphalt	1.44	11.06½	3.1
Rolling asphalt	2.18	16.78½	4.3
Total	47.63	366.79	100.0

As has already been stated, the finished road surface was similar to an asphalt pavement which had been open to traffic for some time in its dark-brown color and smooth even finish. Practically little impression was made on the surface by traffic after a week, except on very warm days, and this was not sufficient to impair its appearance or value. Incisions into the surface revealed a dense coating of dust and sand about one-eighth of an inch in thickness thoroughly incorporated in the bitumen. This served at once as a wearing surface and as a protection to retain the bitumen in the sand below. Only at one or two points did the limestone of the wearing course protrude. This occurred where the rock had been disturbed after it had been rolled and had been forced up into the asphalt layer. Rolling and traffic had left it flush with the surface, however, and its presence was considered as a defect in the appearance rather than in the wearing quality of the roadway.

After four months the appearance of the roadway had undergone no appreciable change. Along the crown a few more particles of limestone were exposed to view. This was undoubtedly due in large measure to the effect of traffic in forcing the asphalt

into the voids of the stone, for a large part of the traffic is confined to the center of the pavement. This development was not regarded as of serious consequence, however, as the rock along the axis of the roadway had been more or less disturbed while the asphalt was being laid, and it is probable that the few protruding stones were those which had been raised above the general plane of the rock surface and were not covered to the same depth by the rock asphalt as surrounding rock. Incisions into the asphalt at this time revealed no perceptible loss by drying or hardening of the bitumen, as the sand particles showed their normal inclination to move when warmed in the hand.

The permanence of macadam construction depends largely upon the nature of the binder used and the ability of traffic to supply by attrition the material which is removed by wind and water. It was to test the adaptability of rock asphalt as such binding material that this piece of construction was undertaken. The pavement formed is dustless. There is no appreciable wear of the surface material to be raised and carried away by the wind as dust and such dirt, as may be carried upon it is readily removed by sweeping or flushing with water. There is sufficient adhesive power in the bitumen to serve as a cement to hold the stone of the wearing course in place, giving at once a smooth and waterproof surface. It is resistant to deformation under a load, yet sufficiently plastic to break the severity of the blow from a horse's hoof, and thus, in a measure, avoids the harmful effects of rigid pavements on animals.

CHAPTER XVI.

METHODS OF SURFACING ROADS.

STARTING with the more lasting and more substantial methods of waterproof surfacing of macadam roads, prominent mention must be made of the system which is the result of two years' careful experiments and research made by George C. Clausen, of the Sicilian Asphalt Paving Co., formerly President of the Board of Park Commissioners in the halcyon days, when the office of Park Commissioner was not given as a "political plum."

In the specifications of the Sicilian Asphalt Paving Co. for roadways for heavy automobile traffic, they first provide as the main supporting body a layer of good sized clean stones, free from all fine stuff, sand, or dirt.

They roll this layer of clean stones until they are crowded firmly together and brought to an even surface. They then apply hot asphalt as a binder, filling the voids and overflowing the top of the layer to receive a coat of small stones which, when kneaded into the surplus asphalt, forms the wearing surface of the road.

To knead the small stones into the asphalt without disturbing the under layer, they use a special heavy steam roller designed for that purpose.

Their method of thoroughly rolling the bed of coarse stones before the asphalt binder is applied produces a strong and stiff under layer which cannot be displaced or flattened out by the traffic. This non-elastic base preserves the grade and crown of the surface layer which is anchored fast to it by the asphalt extending through both layers.

The surface of small stones and asphalt will always be elastic and therefore non-slippery. The wear is very little, the surface being cushioned by the asphalt.

The roadway is dustless and waterproof and cannot be washed out or gullied by storms. It has its full strength and is ready for immediate use when laid.

PENNSYLVANIA RAILROAD STATION, JERSEY CITY, N. J.
Floor covered with Neuchatel Rock Asphalt Coulé Wearing Surface, laid upon 3-inch plank floor.

It is preferred to use the ordinary commercial 1½-inch stone for the under layer of the road, including stones passing a 2½-inch ring and having all that will pass a 1¼-inch ring screened out of it. For the surface, the part screened out can be used, provided it is clean and free from dirt.

Any good macadamized road has stone in it fit for the purpose and can be readily converted to this system, making it dustless and automobile-proof at comparatively little expense.

In August, 1906, there was put down for experimental purposes over 6,000 square yards of this roadway in Bronx Park, New York, near the eastern gate, where the automobile and other traffic is very heavy. It was put down of various thicknesses, in some places very thin indeed and nowhere more than half the thickness called for in their present specifications. They used various compositions of asphalt by means of which they now claim to know exactly which is the best to use.

After two years' use this roadway now stands the heaviest kind of automobile traffic with perfect success, and with remarkably little wear. This example shows that the automobiles cannot strip the surface layer even if only a quarter of an inch thick; that the surface is non-slippery and dustless and though always altstic, that it never forms into waves or gets humpy, but keeps in perfect shape as to crown and grade.

The under layer alone makes a good road and will carry the traffic for a long time if the road is neglected. Repairs can be made at any time without disturbing the surface.

It will be seen that the construction of their roadway is simple and easily understood and that no well-established principle of roadmaking is violated.

The specifications issued by this company are as follows:

SPECIFICATION.

The roadbed must be firm enough to be finished to sub-grade by a 10 to 15-ton roller.

The surface of the roadbed is to be six inches (6") below grade. It must be closely compact and of such a nature that the macadam cannot be pressed into it more than one inch (1") by a 10 to 15-ton roller.

On this roadbed a layer of one and one-half inch (1½") stone is to be evenly spread to a depth of six inches (6"), more or less, as may be needed to bring the surface of the layer when finished to within two inches (2") of grade.

The stones used in this layer must be clean and free from any fine stuff that would act as a binder.

It must be thoroughly rolled with a 10 to 15-ton roller until a firm, unbound surface is obtained, composed exclusively of good-sized stones crowded together, face up, in horizontal alignment.

The aligned surface of the layer being carefully maintained, it is to be flooded with hot "Sicilian asphalto" of a quality as hereinafter specified, so it will flow into and fill all the interstices and voids and at the same time overflow and cover the surface of the layer to a depth not less than three-quarters (¾) of an inch.

The Sicilian Asphalto is a mixture of bituminous ingredients, carefully manipulated so as to make a soft and tough binder, without liquifying injuriously in hot weather.

Hudson River Road Gravel, or a mixture of three-quarter inch (¾") stone and screenings of Trap Rock must now be evenly spread upon the Asphalt, enough to be used to bring the surface of the road to grade when finished.

This material must then be thoroughly kneaded into the Asphalt without disturbing the under layer, and rolled until a smooth, dustless, elastic surface is obtained.

Another excellent device for surfacing macadam is that introduced by the Wadsworth Stone and Paving Company, previously mentioned in the Public Roads Office reports, and is as follows:

SPECIFICATION.

The sub-grade will be brought to an even surface, parallel with the grade proposed for the pavement, by making the necessary excavation or embankment. Soft or spongy earth, or other material not affording a firm foundation, will be removed, and the space filled with sound stone, which shall be solidified by ramming or rolling, as hereinafter provided. The sub-grade surface will be compacted by rolling with a roller operated by steam power and weighing not less than ten (10) tons. Any portion not accessible to roller shall be thoroughly compacted by ramming. When the rolling and ramming shall have been done, the surface shall be true and smooth and eight (8) inches below the proposed finished surface for the pavement.

Upon the sub-grade thus prepared shall be spread an even layer of sound, hard limestone or furnace slag broken into fragments so that the largest diameter of any stone shall not be over 3". The stone or slag must be free from clay or dirt and contain no vegetable or perishable matter. This layer of stone or slag, after the same has been thoroughly rolled shall be 6" thick, and its surfaces shall be parallel with the finished contour of roadway and 2" below same. This layer of stone shall contain an even and uniform amount of screenings, equal to twenty-five (25) per cent. of the total amount of stone, so that the stone can be thoroughly compacted in rolling. This layer of stone, if the contractor sees fit, may be hauled upon the sub-grade, and there broken to the required size.

Upon this layer of stone, prepared as described, there shall be evenly spread a layer of hard, sound, clean limestone, free from screenings, dust or dirt crushed into fragments varying uniformly in size from one and one-half (1½") inches to two and one-half (2½") inches, measured on longest diameter.

This last layer of crushed limestone after being uniformly spread, shall be rolled once. After said rolling, the top layer shal measure two (2) inches. Kentucky Rock Asphalt shall then be hauled on the street in carts or wheelbarrows and dumped, after which it shall be spread and raked with asphalt rakes, in manner satisfactory to the Engineer. This Kentucky Rock Asphalt shall be pulverized and shall contain not less then seven (7) per cent. of natural bitumen. This top surface shall then be thoroughly rolled until the interstices of the crushed stone are entirely filled with Rock Asphalt, and the surface of the roadway is hard and even, and entirely covered with Rock Asphalt; the whole to be satisfactory to the Engineer in charge.

This work must be done in dry and warm weather, with the thermometer showing, not less, than 70 degrees F. If the Asphalt surface of the street should be damp or moist from any cause, it shall not be rolled until the sun has thoroughly dried the surface. Whenever, after one or more rollings, it is found that Rock Asphalt sticks to the roller, the surface of the street shall then be dusted with hydraulic cement to the satisfaction of the Engineer.

The Rock Asphalt shall be so spread upon the street that one (1) ton of 2,000 lbs. will cover, not more, than twenty-five (25) square yards.

The Good Roads Improvement Co. have done work in several sections of the country, using a material known as Asphalt-oiline. This is made from crude oil with the heaviest natural asphaltum base of any oil west of California and contains no paraffine and no sulphur. It is treated and refined to eliminate the volatile matters and other constituents and is a liquid asphalt from 75% to 95% pure, according to grades, and contains sufficient petroleum to secure proper penetration.

Their formula is as follows:

After the road is finished according to specifications for macadamizing to the entire satisfaction of your engineer we agree to put on a coat of liquid asphalt oil to be applied according to the following:

SPECIFICATION.

The prepared roadbed shall be treated by distributing the liquid asphalt oil over the surface of the same, at the rate of not less than ¾ gallon per square yard by means of a machine fitted with an appliance for the purpose and so arranged as to enable the operator to control the flow and distribute the material equally and uniformly, leaving no streaks or spots, and also enable the operator to cut out any part or section to avoid depositing a surplus of the material on the roadway or on railway tracks (if such are located in the roadway), or in the gutters, and to completely control the quantity delivered.

A coat of 50 per cent. ¾-inch stone and 50 per cent. screenings properly mixed is spread to a sufficient thickness to a smooth and uniform surface to the road, then again rolled until the road becomes thoroughly consolidated, hard and smooth. Any depressions formed

during rolling or from any other cause are to be filled in with 1¼-inch stone and screening brought to the proper road grade and curvature as determined by the Engineer.

The Indian Refining Co. sell a blended liquid asphalt from Kentucky—a manufactured product carrying 75 per cent. asphalt in solution fluxed with other constituents of a volatile nâture absolutely free from paraffine and sulphur, the preparation remaining in a fluid condition at a temperature above 50 degrees Fahrenheit, and is entirely free from all the objectionable features of crude oil. It carries a slight odor, not offensive, which disappears entirely in a period of two to five days, which is the time required for the liquid asphalt to properly set and dry upon the surface of the roadway upon which it is applied. It is a scientifically prepared material, which was developed from several years' experiment in treating roads with crude oils for the purpose of eliminating dust.

Petrolithic pavement for city streets and country roads is a California invention. It consists of natural soil, which to a depth of six inches, has been impregnated with crude asphaltic oil, and tamped until it is practically as solid as stone, by means of a Petrolithic Rolling Tamper. The tamping roller to be used in the execution of the work consists of a roller the outer surface of which is studded with teeth not less than seven inches long and having a surface area of not less than four square inches each, the roller itself is of such a weight that the load upon each tooth is not to be less than three hundred pounds.

In April, 1905, the City Engineer of Los Angeles, Cal., gave the author the following specifications for surfacing roadways:

SPECIFICATION.

Upon the surface prepared and brought to sub-grade shall be spread in the following described manner: Two layers of gravel, of the same quality as that composing the natural surface of the street, the bottom layer to have a thickness of five inches, and the top layer to have a thickness of three inches after having been rolled. The first layer, which shall contain no stones larger than two and one-half inches in greatest diameter, is to be uniformly spread upon the roadway, and well moistened. The gravel shall be well rammed for at least one foot from the gutters, should these be paved, or if the gutters are not paved, then one foot from the curb. The remaining portion of the roadway shall then be rolled with a roller weighing not less than 250 pounds to the inch width of tire. The rolling of the roadway shall commence at the rammed portion. All depressions must be promptly filled, moistened and again rolled. The rolling must be continued until the surface wil not yield under a roller of the weight above described.

CARNEGIE LIBRARY, YONKERS, N. Y.
Five-ply gravel and asphalt roof. Rock asphalt paving in yard around the building.
Laid by J. E. Pawson & Company, Yonkers.

On this surface shall be spread the top layer, which shall be raked free from all stones larger than one-half inch in greatest diameter. If no gutters are provided, these larger stones shall be raked to the curb and distributed over a strip two feet in width next to the curb. If gutters are provided then these stones shall be distributed on a strip of two feet in width next to the gutter. The top layer of gravel shall then be thoroughly compacted by ramming and rolling in the same manner as specified for the first layer.

The entire surface between the gutter lines, if there be gutters, or between the curb lines if there be no gutters, which shall have been rendered perfectly smooth and hard by the process above specified, shall then be broken to a depth of not less than two inches by a fine tooth harrow, or some similar apparatus, dragged in every direction over it, until no part remains untouched. Oil shall then be even distributed over the surface in a volume equal to, but not exceeding, the amount the surface of the street will absorb in such manner that no oil shall remain on the surface.

After a lapse of not less than twelve hours the surface shall be again harrowed, and receive a second application of oil. Any part of the street, upon which a portion of the oil or the residue thereof may be seen, shall then be sprinkled with sufficient sharp sand to absorb the same, and any portions that appear too dry shall receive a further light application of oil.

The entire surface shall then be thoroughly mixed and receive a light covering of sand, and be thoroughly rolled and trimmed until no evidence of oil remains, except the coloring of the gravel.

The total amount of oil used shall not be less than three gallons per square yard of the street surface. The oil used shall be crude petroleum of a density between 11 and 14 degrees gravity Baume, asphaltum base, and shall be applied at a temperature not less than 150 degrees Fahr.

CHAPTER XVII.

ASPHALTIC OILS, THEIR CLASSIFICATION AND PROPERTIES.

OILS as a class are fatty organic substances derived from innumerable sources. They may be most conveniently divided under three heads, as animal, vegetable, and mineral. While oils of the first two classes have been used to some extent as dust preventives, mineral oils are by far the most important, and have been most generally used for this purpose. As animal and vegetable oils, owing to their lack of heavy binding bases, may be ranked as temporary binders, they may be considered most conveniently with the lighter mineral oils and emulsions, which will be taken up later.

The value of an oil as a permanent dust preventive lies in the quality and quantity of high-binding bituminous base retained by the road surface after evaportion of the more volatile constituents. The bases present in petroleums vary from those of almost pure paraffin to almost pure asphalt, many being mixtures of the two. While the paraffin oils are of much more value than the asphalt from a commercial point of view, the opposite is true from the standpoint of their use in dust suppression. An oil wholly paraffin is of value only as a temporary binder or dust layer. Petroleum is a mixture of a great number of organic bodies known as hydrocarbons, together with small quantities of sulphureted, nitrogenized, and oxygenated compounds. The approximate composition of crude petroleum is ordinarily determined by distillation, but a knowledge of the residuums left after distillation is of fare value from the standpoint of dust suppression.

There are seven distinct oil fields in the United States, which yield oils differing in qualities. The Appalachian, which includes the States of New York, Pennsylvania, West Virginia, southeastern Ohio, and parts of Kentucky and Tennessee, produces oils which are known as eastern oils or paraffin petroleums, and

which are therefore of use only as temporary binders in dust suppression. The Ohio-Indiana field produces oils which are much like those of the Appalachian and are also classed as paraffin oils; and the same is true of the colorado oils. The Wyoming oils vary in character from the lighter to the heavy asphaltic oils which are found principally in California. The oils from the California field, while of the most varied character, consist mainly of more or less dense asphaltic hydrocarbons. None of the components are of the paraffin series, and, as the percentage of asphatlic residue in these oils is usually high and of a good binding character, they may be considered the best for use as permanent binders. Oils from the Texas field are of a mixed character. All of them contain some paraffin as well as a greater or less amount of asphaltic residue. Some have been used successfully as dust preventives, while others are unfit for this purpose. It is needless to say that their value lies in the relative amounts of asphaltic and paraffin base contained. The Kansas oil field, including Oklahoma, produces oils quite similar to those from the Texas field and shows a mixed paraffin and asphaltic base. The Louisiana field also yields oils similar to the Texas. Some of the wells in the Indiana and Kentucky fields have also been successfully used. In general, however, the eastern oils are of the paraffin type and useless as permanent binders; the western oils are of asphaltic character and of great value as permanent binders, while the southern oils are of a mixed character, containing part paraffin and part asphalt bases, their value as dust preventives lying in the relative amount of asphalt base contained.

While crude oil has been used to a great extent in the West for the purpose of dust prevention, it is often customary in the East to partially distill oils containing asphaltic residues before using them in this connection. By this means many of the more valuable constituents are recovered and the residual oils produced have a much better binding quality, owing to the fact that they contain a larger percentage of asphaltic base. A brief description of the principal processes of oil refining and of the properties possessed by different types of refined oils will therefore be given.

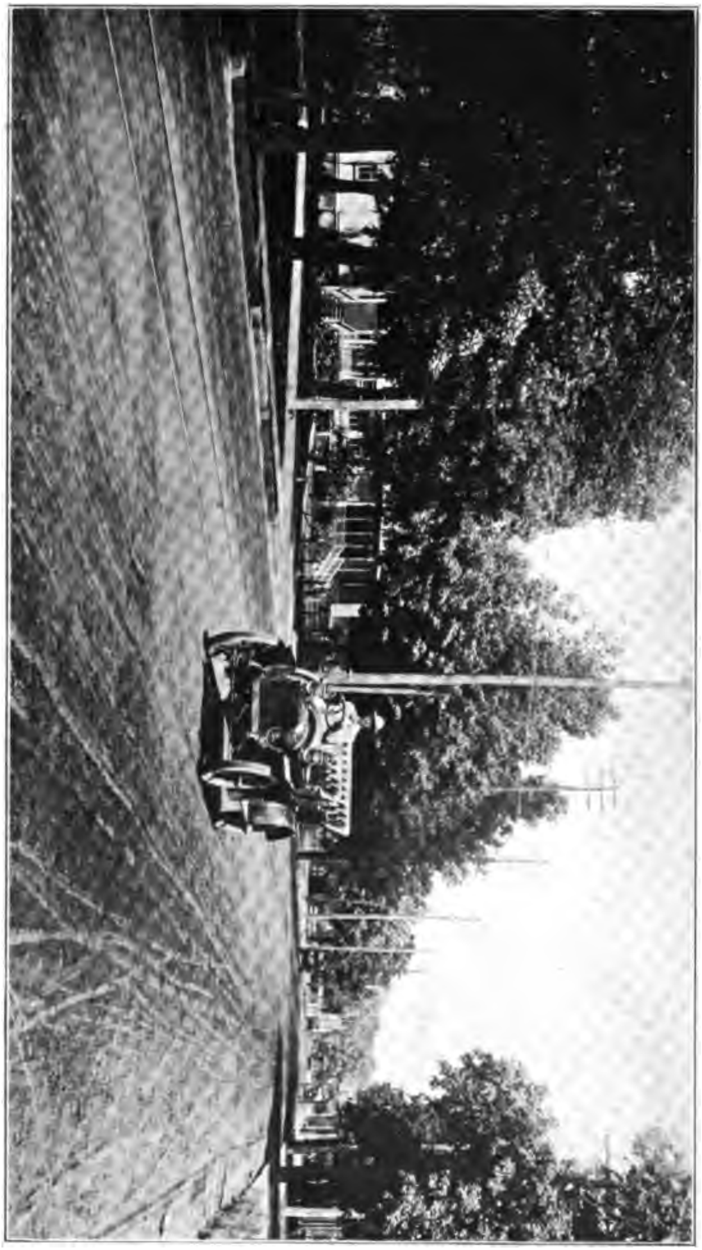
Crude petroleum is an only liquid of rather unpleasant odor, with a specific gravity ranging from 0.73 to 0.97, according to the locality from which it is derived. It varies in color from greenish brown to nearly black and often exhibits a reddish brown or

orange color when viewed by transmitted light. It is also somewhat fluorescent. Sand and water are often mixed with the crude oil, but these separate and settle upon standing in the storage tanks. In order to recover various products from the crude petroleum, it is subjected to a process of refining by means of fractional distillation in a manner somewhat similar to that employed for the refining of crude coal tar.

The most valuable products are the kerosene, or burning oils, and a method known as "cracking," which increases their yield, is very generally employed. This is accomplished at a certain stage of the distillation by modifying the fire so that only the bottom of the still is subjected to a great heat, while the top and sides, being exposed to the air, become somewhat cooled. By this means the heavy oil vapors are condensed within the the still itself, and upon dropping back into the residium, which is much hotter than their boiling point, break up into lighter oils with lower boiling points with a separation at the same time of free carbon or coke, which is deposited in the residium. Here we have a condition somewhat similar to that encountered in the case of coal tar produced at a high temperature. As the free carbon is not a binder, it is useless in a dust preventive, and when present in large amounts is apt to produce the same bad effects in an oil as in a tar.

The residium of the various petroleums have been used to a great extent as fluxes for softening the solid native bitumens used in the paving industries. Their various characteristics and propreties have therefore been given considerable study. As the character of the residues present in both the crude and refined petroleums is of the greatest importance from the standpoint of dust suppression, the results obtained from a study of these fluxes should be of service in determining the suitability of various oils for this purpose. The character of the residue will naturally vary as the crude petroleums vary, although, as has been shown, the method of preparation may produce considerable effect upon the residue.

The paraffin petroleum residuums are of a soft, greasy character and, as their name implies, contain a large amount of paraffin hydrocarbons and paraffin scale or crude paraffin. A road surface treated with material of this character will be dustless for the time being, but in damp, rainy weather will become cov-



MAMARONECK AVENUE, WHITE PLAINS, N. Y.
Treated with Standard Asphalt Road Oil.

ered with a slimy, greasy mud, which is easily washed away and leaves the road is as bad, if not worse, condition than it was before treatment. When the crude or even the residual oil is used solely as a binder, it may therefore be predicted that the outcome will prove a failure.

The base held by the California petroleums is composed of bitumens resembling asphalt. The residium contains no paraffin and, if cracking has not been employed in its preparation, carries but little free carbon. The specifications for California fluxes call for not over 6 per cent. fixed carbon. Both the crude oil and the residiums, if properly prepared, act as excellent binders and have, as a rule, given the best results of any oils which have been used as dust preventives.

The semi-asphaltic oils, such as those obtained from Texas, carry an aphaltic base, but also a considerable amount of paraffin hydrocarbons and a little over 1 per cent. of paraffin scale. While somewhat inferior to the California products, good results have often been obtained from their use on roads in both the crude and the refined state. Those which contain the greatest amount of heavy binding bitumens and the least amount of paraffin scale are, of course, to be preferred. In order to obtain the best results the residiuums, as well as the crude oils of asphaltic or semi-asphaltic character, should be comparatively free from water.

Sometimes the residues from the distillation of petroleum, while yet hot, are subjected to the action of a jet of air, which has a tendency to thicken or harden them. It is doubtful, however, if an oil thus treated will be improved for use as a dust preventive, as the life of the oil is apt to be destroyed and its lasting qualities as a binder lessened.

The use of a paraffin petroleum is to be avoided, as a good crude product is to be preferred to a badly cracked residiuum or one produced from a poor quality of crude petroleum. Considerable attention has been paid to the actual quality of oils which have been employed as dust preventives. A number of specially prepared or refined oil products are now on the market for use on roads, both in the form of residiuums and emulsions. The residuum products have been prepared from asphaltic or semi-asphaltic oils by methods similar to those described, while the emulsions are usually residuums which have been treated with saponifying agents in order to make them miscible with water.

Owing to the fact that oils from a number of wells are commonly run through the same pipe lines from the wells to the storage tanks, it is often difficult to obtain two lots of oil having exactly the same properties, even when purchased from the same source. It is very important, therefore, that an examination of each lot of oil be made before attempting to use it for the purpose of dust prevention. Sometimes a partial chemical analysis is necessary, but in the majority of cases a few simple tests will determine its suitability for this purpose. These methods of examination are described later. It is also a wise measure to examine residuums even when they are especially advertised as road preparations, for, as has been stated, there is a strong tendency among refiners to crack their oils in order to increase the yield of illuminants, and when this is done the value of the residiuum for the purpose of dust prevention will be considerably lessened. If the road engineer understands thoroughly the propeties possessed by the oil which he is handling, he will be able to avoid many dismal failures which might otherwise occur.

Some of the results obtained from an examination of various crude and refined petroleums in the New York Testing Laboratory are given in the following tables in order to show the differences in properties possessed by the different kinds of material. They do not in any sense represent absolute values for the different classes of oils, but will serve to give a general idea of the relative characteristics of each.

TABLE IX.

RESULTS OF TESTS OF CRUDE PETROLEUMS.

Kind of oil.	Specific gravity.	Flashing point. °C.	Volatility at 110° C., 7 hrs. %	Volatility at 160° C., 7 hrs. %	Volatility at 205° C., 7 hrs. %	Residue. %
Pennsylvania, paraffin	0.801	(a)	47.8	58.0	68.0	b32.0
Texas, semi-asphaltic	.904	43	20.0	27.0	49.0	c51.0
California, asphaltic	.939	26	....	....	d42.7	e57.3

aOrdinary temperature.
bSoft.
cQuick flow.
dVolatility at 200°, 7 hrs.
eSoft maltha; sticky.

It will be noticed from the foregoing results that in the samples examined the specific gravity increases from the paraffin to the asphaltic oil. This is also true of the percentage of residue, while the volatility decreases correspondingly. The residues

range in character from soft and probably greasy through an intermediate and but slightly viscous stage to the more or less liquid maltha of good adhesive properties. A rough idea of the character of these bases may be formed by rubbing a little of the residue or even of the crude oil between the finger and thumb. Those of a paraffin nature will feel greasy, while those of an asphaltic character will often exhibit an adhesiveness which is easily distinguishable. The color and odor will also indicate the character of the crude material to those familiar with the different varieties. In comparing the Pennsylvania with the Texas oil, it will be seen that the former carries a higher per cent. of light oils than the latter. A comparison of the residuums obtained from refining oils similar to those described in the above table is shown in the following table:

TABLE X.

RESULTS OF TESTS OF PETROLEUM RESIDUUMS.

Kind of oil.	Specific gravity.	Flashing point.	Volatility at 200° C., 7 hrs.	Residue.	Solid paraffin.	Fixed carbon.
		°C.	%	%	%	%
Pennsylvania, paraffin	0.920	186	14.2	a85.8	11.0	3.0
Texas, semi-asphaltic..........	.974	214	6.2	a93.8	1.7	3.5
California, asphaltic	1.006	191	17.3	a82.7	0.0	6.0

aSoft.

In comparing these results an increase in specific gravities in the same direction as in the case of the crude petroleums will be noticed. The volatility and percentage of residue, however, are not in the same order. As these are dependent entirely upon the point at which distillation is stopped in the process of refining, such a result is to be expected. The percentage of solid paraffins is found to decrease to zero as the character of the oil becomes asphaltic. Only 11 per cent. was found in this particular sample from Pennsylvania, but it is not uncommon for oils of this nature to carry as high as 33 per cent. paraffin. The amount of fixed carbon is found to increase with the asphaltic character of the oil, and this fact is quite general, owing to the greater tendency of the asphaltic oils to crack during distillation.

In comparing the crude oils with the residuums, it will be seen that the latter, as would naturally be supposed, carry a greater percentage of residue, and, other things being equal, are

therefore of more value as permanent binders. A considerable difference is also seen to exist between their flash points, which is the temperature at which their most volatile products flash when brought in contact with a flame. As a general rule, it is not difficult to distinguish between a crude and a residual oil, but in cases where any doubt may exist the flash point is a fairly accurate indicator. Thus, in the case of the crude Texas oil and the Pennsylvania residuum, we find that their specific gravities are quite close together, and some doubt might exist as to which was crude and which residual. A determination of their flash points would at once settle this question.

VIEW OF STOCKTON DRIVE, CHICAGO, ILL.
This Mineral Rubber Asphalt Macadam was laid by The Standard Asphalt & Rubber Company, of New York and Chicago.

Chapter XVIII.

APPLICATION OF ASPHALTIC OILS.

MANY valuable facts have been learned in regard to the application of oils to road surfaces, although, owing to contradictory results, considerable differences in opinion seem to exist as to the actual and relative values of different kinds of oils under the same conditions and under varying conditions. This is, to a great extent, due to lack of knowledge in regard to the properties of the material used and to the fact that climatic conditions and the character of the road treated have a much more important bearing upon the results than is usually realized.

The subject of oil application has received considerably more study in our country than has been given it by European nations. It is true that various experiments have been carried on in England and France with a number of different oils, but owing to the lack of a proper base in these oils the results have been discouraging. Shale oils and Russian petroleum residuums, known as "masut" or "astatki," have been employed, as well as certain vegetable oils, such as oil of aloes. They have all been found effective as temporary dust preventives, but in rainy weather produce a greasy, disagreeable mud and soon disappear from the road surface. The best results have so far been obtained with heavy oils applied in the form of a spray while hot.

As the application of the temporary binders or lighter oils can best be considered in connection with that of oil emulsions, the application of the heavier oils only will be taken up here. Crude petroleum, as well as residuums and specially prepared oils, have been used with more or less success on earth and gravel roads, as well as on stone roads.

APPLICATION TO MACADAM SURFACES.

In applying oil to a macadam surface, holes and inequalities should be repaired; it has not been found necessary to remove all

dust from the road surface, but sticks, leaves and other detritus fo an organic nature should be removed.

The crude or refined oil may be applied either cold or hot, according to its viscosity and ability to penetrate the road surface. The application of cold oil is considerably the cheaper and is to be preferred on that account. Most crude oils and some of the lighter residuums have been used in this way with good results, but it has been found necessary to heat the heavier products before application.

If much work of this kind is to be carried on in one locality, it is sometimes the custom to erect a stationary heating plant at a convenient railroad siding. A plant of this sort has been described in a previous publication,* and consists of a receiving tank of one tank-car capacity placed preferably so that the oil may be run in by gravity from the car. A heating tank set at an elevation sufficient to allow the hot oil to run into the distribuing wagons and fitted with steam coils through which superheated steam may be forced is placed near the receiving tank. The oil may be pumped into this heating tank as required and heated to any desired temperature. Very often the heating is carried on in the tank car, and the hot oil run directly into the distributing wagon. When sufficiently fluid, it can then be applied to the road by means of a large pipe and broomed into the surface in the same manner as tar. Patented distributing devices have been employed which can be attached to almost any form of tank wagon and which, if the oil is fluid enough, will do away with the necessity of brooming. An oil applied by this means will, however, have to be heated to a higher temperature than in the former case, as the openings in the distributer are of small dimensions and will not allow the oil to pass freely if it is in a very viscous state.

The main object is to obtain an even coating, which shall be well absorbed by the road surface. The application of a large excess of oil should be avoided, as it is sure to make the surafce sticky and disagreeable. A covering of sharp sand or one-half-inch stone screenings should be applied after the oil has been allowed to penetrate as much as possible, in order to take up all excess, and the surface thus formed should be rolled until well compacted, additional sand or screenings being thrown on where-

*Use of Mineral Oil in Road Improvement, Yearbook Dept. Agric., 1902, p. 446.

ever the oil shows a tendency to force its way to the surface and produce a sticky condition. Sometimes two or three courses of oil and screenings are applied. It is usually considered better to allow the freshly oiled road to dry out to some extent before applying the top dressing, but in cases where it is impossible to keep traffic away the same methods may be employed as in the case of tar, i. e., either one-half the width of the road may be treated at one time or the sand or screenings may be applied at once. If the oil is well absorbed it is not always necessary to employe the roller, as ordinary traffic will consolidate the surface in the course of time.

APPLICATION DURING CONSTRUCTION OF MACADAM ROAD.

The application of oil during process of construction has been carried on with the greatest success in California, where the heaviest asphaltic oils are found. The residuums obtained from the partial distillation of these oils have so far given the best results when properly applied. The treatment is essentially the same as with tar, the object being to build a road containing a low percentage of voids, so that the oil will act as a binder only and the strain of traffic be borne by the road stone. Considerable attention should be paid to proper drainage of the road, as it is essential that the foundation be perfectly dry. The macadam is built in the usual manner and each course thoroughly rolled until the whole road is well consolidated. If water is used during the process of construction sufficient time should be given for the road to become perfectly dry before applying the oil. The hot oil is applied by means of a tank wagon fitted with a distributing device which insures an even distribution. Any excess of oil is taken up by the application of a sufficient covering of sand and screenings, and the road is then opened to traffic.

A road constructed in this manner will usually require from ¾ to 1½ gallons of oil per square yard, depending upon the quality of oil employed and kind of road surface treated.

The softer and more porous rocks, such as limestone, permit of a better penetration than the harder rocks, such as trap and granite, but good results have been obtained by the use of both kinds. Oils as a class seem to penetrate better than tars, as they do not harden as quiclky upon exposure to the air. In order to

keep the road in proper condition, repairs should be made as often as necessary, and in the same manner as in the case of tars. By this means rapid disintegration will be prevented, which would otherwise occur if water were allowed to accumulate in the worn places.

APPLICATION TO GRAVEL ROADS.

A gravel road is oiled in much the same way whether it is an old road or one under construction, as only the upper course is treated in either case. It is especialy important in a road of this kind that the drainage be good, and this matter should be attended to first of all. Any holes or pockets which may exist should be cleared out, if much fine material is present, and filled with clean, fresh gravel, so that the surface of the road will be uniform when the patches have been sprinkled and rolled. If the lateral drainage is bad, the entire surface should be loosened and brought to proper grade and crown by the addition of new material before the oil is applied. In this case more oil will be required to effect a good bond than if the old-compacted surface was treated, but the results will be of a more lasting character. The oil may be applied either cold or hot, according to its viscosity, by any of the methods already described. It should contain a high percentage of good asphaltic base, or otherwise the material near the surface will become loose, owing to the lubricating qualities of the oil. The use of too much oil should be especially avoided, and all excess should be taken up by the addition of fresh gravel. Where the surface treated is loose and contains a considerable amount of clay, the oil may be worked into the upper course by raking, which insures an equal distribution. After application of the oil, the road should be rolled until properly compacted, and as this is apt to bring some of the oil to the surface, fresh material should be added where necessary. If the freshly oiled road is not well rolled, the action of traffic will bring the oil upward; a soft spongy surface condition will be produced; loose, oily particles will be thrown out by rapidly moving vehicles; and the oil will be tracked by pedestrians.

Oil is applied to a gravel road during construction in a manner quite similar to that already described, but certain points in regard to the method of construction should be noted. These facts are well presented by the Commissioner of the Department of Highways of California* in a report which contains specifications

*Biennial report, 1906.

WILLETT'S ROAD (OILED), LONG ISLAND, N. Y.
Oiled with Gulf Refining Company (Asphaltum) Road Oil.

used in certain parts of that State for the construction of oiled graveled streets. As California has been most successful in this kind of work, a study of the methods used there should be of great value to experimenters in other localities. Certain portions of these specifications in condensed form are given below for the purpose of emphasizing the most essential points.

Before placing the gravel the subsurface must be brought to grade and rolled. Upon this subsurface two layers fo good gravel should be applied, the bottom layer having a thickness of 5 inches and the top a thickness of 3 inches after being rolled. The first layer should contain no stones larger than 2½ inches in greatest diameter. The gravel must be uniformly spread on the roadway and well moistened, rammed 1 foot from the gutter or curb, and the remaining portion rolled with a roller of the type before specified. All depressions must be promptly filled, moistened, and again rolled, the rolling being continued until the surface will not yield under the roller. On this surface the top layer of gravel, free from all stones larger than 1 inch in greatest diameter, should be applied and compacted in the same manner as the first layer. Oil should then be evenly distributed over the entire surface at the rate of one-half gallon per square yard, and covered with clean, sharp sand until no oil can be seen. After the lapse of not less than twelve hours, another application of oil should be made and sand distributed in the same manner and the whole surface rolled until unyielding to the roller, as before described.

These specifications require that the oil be crude and that it be applied at a temperature not less than 150° F. nor above 190° F. Certain methods of testing the properties of the oil are included in the specifications, and a consideration of these tests will be found later. In regard to measuring the petroleum, however, it may be said that the volume at 60° F. is taken as normal, and a deduction of 0.1 per cent. is made for every 10° increase over this normal temperature as a correction for expansion by heat.

USE OF OIL ON EARTH ROADS.

The use of oil on earth roads was first tried in this country in California. Crude petroleum was sprinkled upon the road for

the purpose of laying the dust only. It proved to be a very effective dust layer, and in some cases improved the condition of the road surface to such an extent that popular attention was aroused, and as a result many experiments were made with a view not only to laying the dust, but to hardening the surface. Since then oil has been used with varying success and failure, and much valuable information has been derived from the experiments. California is particularly favored for work of this nature, owing to its climate and the character of its roads, as well as to the excellent road-building properties of its oils. Although it is impossible to duplicate these conditions in other localities, the lessons learned from the numerous experiments conducted in this State are of great interest as offering suggestions for work of a similar nature in other places.

It has been found that the character of the soil plays a most portant part in the results obtained, and different kinds of soils have to be treated in different ways. Alkali soils disintegrate the oil and destroy its binding qualities. A sandy loam is the most suitable for treatment, and almost invariably gives good results when treated in the proper manner with an oil of good binding quality. From a physical standpoint clay is probably the worst of all, as it does not absorb the oil well and exhibits a tendency to ball up and give trouble. Sand should therefore be added to the clayey surface until this difficulty is overcome. As in the case of gravel roads, special attention should be paid to drainage, and the roadbed should be dry when the oil is applied. If the foundation is water-soaked, it soon loses its ability to support the surface properly, which will then break through in weak spots.

The use of too much oil should be avoided, as it will produce a spongy surface condition and increase the draft of vehicles to a considerable extent. It is most important to keep a road thus treated in good repair. Whenever a rut or hole develops it should be cut out, oil should be poured in, and it should be filled up with good earth or sand. The loose material should then be thoroughly tamped until even with the surrunding surface.

Besides the method of oiling earth roads already described, another has recently been employed with considerable success in California. This mthod differs from the other in two essential particulars. The first of these is that water is applied during the process of oiling, and the second that consolidation is produced by

a special tamping device. The method has given satisfactory results with sand and clay roads, as well as with loam and gravel, and is conducted as follows:

The road is first plowed up to the depth of 6 inches and properly crowned. All clods and lumps are then thoroughly broken up by means of a harrow, and the roadway is well sprinkled with water. A specially constructed rolling tamper is then used by which the lower portion of the loose earth is compacted to a depth of about 2 inches, except in cases where the subgrade is unusually firm.

After the lower portion is made firm by this means a heavy asphaltic oil is applied at the rate of about 1½ gallons per square yard, and a cultivator is passed over the road until the oil and earth are thoroughly mixed. The tamper is then used again, and the road is further compactd until only 1½ inches of loose mateiial remain on top. This is lightly harrowed and sufficient water is added to moisten it. Oil is again applied, and the surface is rolled with the tamper until firm, and finally it is ironed down with an ordinary roller additional applications of earth bein made wherever necessary to take up any excess of oil.

A road constructed in this manner will require from 2½ to 3 gallons of oil per square yard. It is hard and dustless and resembles asphalt.

The California oils are best adapted for this method of road building, but the cost of transportation to the Eastern States at the present time raises the price to a prohibitive figure. The Texas and some of the Kentucky oils are the best available for these localities, and range in price from about 4 to 8 cents per gallon, according to locality. The residuums and special preparations vary from 2 to 12 cents per gallon. It is impossible to estimate cost of application except for individual cases.

All kinds of properly oiled roads are dustless, noiseless, waterproof, and resilient, and offer but little resistance to traffic. The crude oils have a rather unpleasant odor, which soon passes away. Both the crude and residual oils exhibit a somewhat weak germicidal action. If an excess of oil is present upon the road surface, an oiled mud is formed in wet weather which is damaging to clothes and the paint on vehicles, but this condition is not met with if the proper amount of the right kind of oil is employed.

WATER AND SALT SOLUTIONS.

The temporary binders as previously defined are materials which have to be applied at more or less frequent intervals in order to suppress dust. Their primary object is to lay the dust only, although they may also tend to preserve the road from wear. No distinct line can be drawn between the permanent and temporary binders, but in general the latter class may be said to embrace water, salt solutions, the lighter oils and tars, and various emulsions.

SPECIFICATIONS FOR MINERAL OILS TO BE USED AS DUST PREVENTIVES OR ROAD PRESERVATIVES.

As oils may be used on almost any kind of road either as temporary or permanent binders, their requisite qualities will depend upon the use to which they will be put. Almost any asphaltic or semi-asphaltic oil will prove satisfactory as a temporary binder if properly applied either in the form of an emulsion or in its natural state. Specifications for the properties of permanent binders only will therefore be considered.

According to Ellery a good road oil should contain at least 40 per cent. of commercial "D" grade asphalt, having a penetration of 60° and no more than 3 per cent. of foreign matter and water. When employed in the construction of oiled graveled streets at Los Angeles, Cal., the following specifications* were adopted for crude oil:

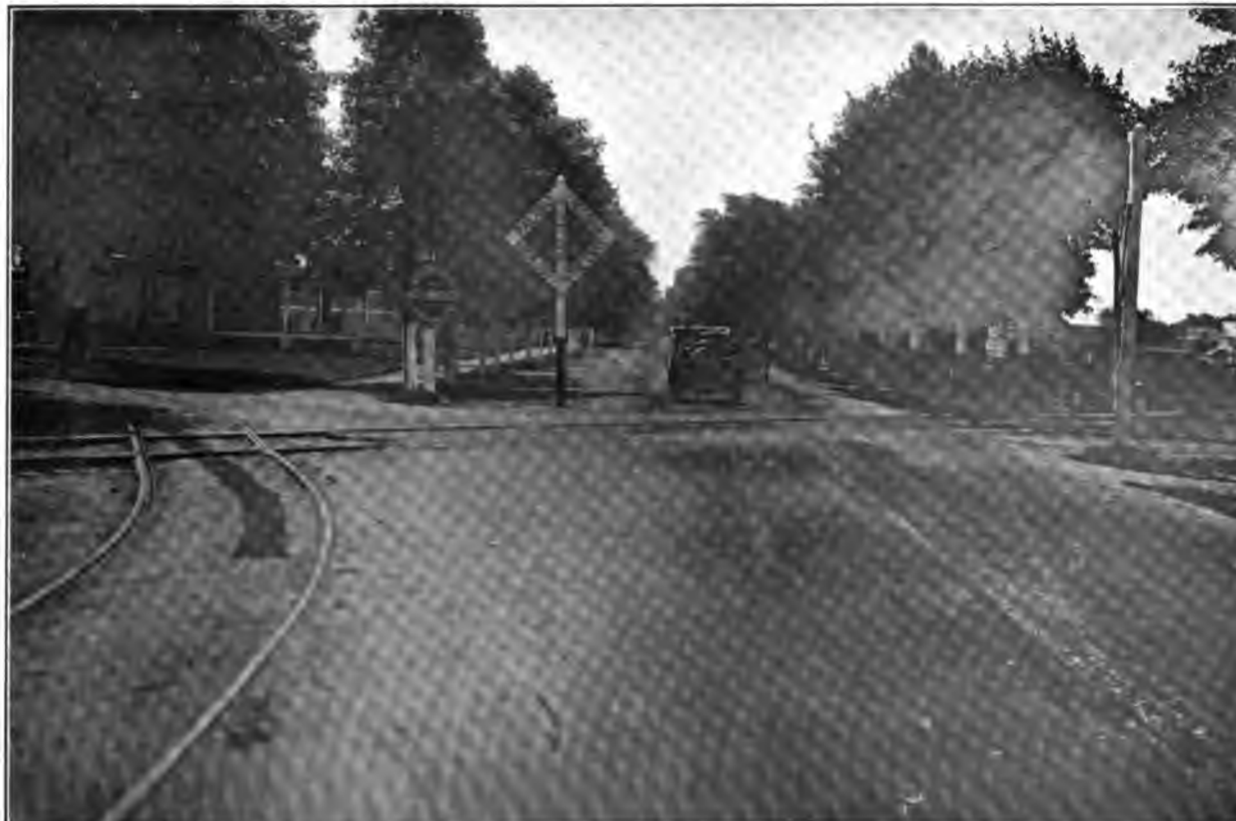
The specific gravity shall not be lower than 10° (1.000) nor higher than 11° Baumé (0.993).

All crude petroleum shall contain not less than 70 per cent. "D" grade asphalt, California standard.

All crude petroleum shall be tested for water and sediment. Deductions for water and sediment in crude petroleum will be made in exact proportion to the percentage of such water and sediment found.

In the construction of asphaltic oiled and tamper-rolled dirt roads at Santa Monica, Cal., the following characteristics were specified:

*Biennial Report of the Dept. of Highways of California, 1906, p. 44.



FRANKLIN AVENUE, HEMPSTEAD, N. Y.
Six months after treatment with Liquid Asphalt by The Indian Refining Company.

The oil shall be from 12° to 14° Baumé (0.986-0.972) test at a temperature of 60° F. and contain not less than 70 per cent. of pure liquid asphaltum, natural non-processed oil to be subject to gasoline test for water and foreign matter, and not to contain over 2 er cent. of water or foreign matter.

From experiments conducted by the Office of Public Roads it would seem that only reduced or residual oils are apt to prove satisfactory as permanent binders if they are semi-asphaltic in character. The following specifications are therefore suggested for this class of oils:

1. The oil shall have a specific gravity of not less than 0.95.

2. Its flash point shall be not lower than 300° F.

3. It shall be free from water as determined by the gasoline test.

4. When heated to 400° F. in the manner previously described for seven hours its loss in weight should not be over 35 per cent. The character of the residue should be smooth and nearly solid when cold, but not so hard that it may not be easily dented with the finger, and when soft it should pull to a long, thin thread.

5. The oil shall be soluble in carbon disulphide to the extent of 98 per cent., and in 88° naphtha to at least 88 per cent.

The methods of examination and specifications for asphalt and other solid materials have not been considered in this chapter for obvious reasons. They belong to works on the subject of pavements. In conclusion it may be said while specifications for dust preventives and road preservatives should prove of great service in most cases in securing proper materials they are of no value unless the proper method of applying the material to the road is employed. So far as possible these methods have been outlined, but local conditions will often necessitate modifications, and much will therefore depend upon the experimenter or overseer of the work.

Chapter XIX.

SPRINKLING WITH ASPHALTIC OILS.

THE Standard Oil Company is now putting out an asphalt oil under the brand of "Standard Asphalt Road Oil," it is a dust layer and at the same time a surface binder. The customary plan is for the municipalities to purchase the oil in tank cars, and either sprinkle it with their own labor or have some local contractor do the work, using an ordinary watering cart. From one-third to one-half gallon of oil per square yard of surface will produce good results, the quantity used depending upon the nature and condition of the road.

The New York State Engineering Department has used large quantities of "Standard Asphalt Road Oil," treating State roads at Port Jervis, Mt. Upton, Schuylerville and other points. County roads have been oiled at Yonkers, Rye, Port Chester, Pleasantville, White Plains and Hartsdale, New York. Norwalk, Darien, Fairfield and Greenwich, Connecticut, and numerous other towns, and the results have been more than gratifying.

In many cases the cost of oiling is less than water sprinkling, from the fact that it is only necessary to oil once a season, whereas water sprinkling is a daily affair.

The Standard Oil Company also have an asphalt binder, known as "Standard Macadam Asphalt Binder," this is a heavy limped asphalt used in the construction of roads where asphaltic material is used. Roads of this character are sure to come in the East, California having demonstrated their durability and superiority over the ordinary macadam road. At Rye, N. Y., 6½ miles of road are being built using the Asphalt Binder in its construction.

The Standard Oil Company, realizing the constantly increasing demand for asphalt oil for surfacing roads has created a distinct department for supplying the same, not only to municipalities but to private individuals under the management of Mr. Henry Fisher.

In this connection the report of W. H. Dunn, Superintendent of Parks to the Board of Park Commissioners, Kansas City, Mo., April 20, 1908, on "Oiling Roads," is interesting. He stated that undoubtedly the most important item of road maintenance for the past fiscal year has been the remarkably good results obtained from oiling.

Continuing the experiment with oil on rock roads, begun in the summer of 1906, the entire system of driveways was, in 1907, treated with residuum oil, now commonly called road oil. He continued:

"I attribute our success, in a large measure, to the fact that we had well-built macadam roads to begin with, demonstrating that, when to a perfectly built macadam road with a solid foundation and hard, smooth surface, is added the road oil for a dust preventive and protection to wearing surface, an inexpensive treatment is given that proves remarkable in its results.

"Our roads to-day, after one year's trial, are in excellent condition, have gone through the winter with less breaking up from freezing and thawing than usual, and without a particle of dust after having been once oiled, and without attention beyond the ordinary sweeping.

"Aside from its value as a dust preventive, the oiled road shows this interesting item of reduction in maintenance expense:

"Sprinkling driveways with water, for the fiscal year ending April 15, 1907, cost $14,011.32, or an average of 2.4 cents per square yard. The area of pavement to have been sprinkled in 1907 (had not oil been applied) would have cost $16,207.32.

"The total cost of oiling for the year was $10,671.44, a direct saving in the one item of sprinkling of $5,538.88, or 34 per cent.

"I believe with an occasional light application of oil through this season we will still improve the wearing surface of our roads, and eventually obtain an ideal dustless pleasure drive.

"The damage to wearing surface comes largely from attrition of the grit or dust on the roadway. Oil compacts this grit or dust, and immediately checks deterioration from this source, preventing any damaging effect from automobile travel.

"The road oil available for Kansas City is a paraffine base oil, and becomes somewhat slippery when applied on steep grades, but is not noticeable on moderate grades. To overcome this objection, a mixture of commercial asphalt with residuum oil has been

tried on The Paseo from Howard to Twenty-fourth Streets, with excellent results, and further experiments will be made this year with this material and with an asphaltic oil from the Kentucky field; with this character of oil, on grades exceeding 4 per cent., I feel sure we will have largely solved the dust problem in a manner satisfactory to all concerned.

"I submit the following statement of oiling operations for 1907, somewhat in detail, covering the oiling operations for the past season with a plan of the unloading tanks and method of application.

"Two steel receiving tanks of 8,000 gallons capacity each were erected near our spur track on the Belt Railway, as illustrated. The railroad tracks at this point are at sufficient elevation to permit unloading tank cars by gravity, the receiving tanks also being at such height as to allow the sprinkling wagons to load by gravity. A four-inch pipe line connects the receiving tanks to a short upright pipe in the center of switch track, which is connected to the outlet in bottom of tank car by a short piece of adjustable six-inch hose, fastened with iron clamps around outside of pipes.

"A portable four-horse power boiler is erected, with 3/4-inch steam pipe running to each tank, which provides ample steam to heat the oil so it will run freely and remain warm until delivered on the street.

"This plant for unloading has worked very efficiently and cost, erected and all connected up, approximately $750.00.

"It was found to be not essential to heat the oil handled in hot weather, after the middle of June, and until the middle of September the oil ran freely, and no particular object was gained by heating.

"Adapting the ordinary street sprinkling cart for distributing oil on the street was a very simple matter, consisting of simply attaching a tin trough six inches in width, six inches in depth, and long enough to enclose the discharge valves, perforated with 1/4-inch holes about one and one-half inches apart. The oil allowed to come into this trough through the valves is then evenly distributed over the road.

"Applying oil to the roadway by any process is dirty work and will inconvenience the public for a short time while the road is being treated. To avoid accidents, barricade the section to be

PARK AVENUE, EAST ORANGE, N. J.
Treated with Asphaltoilene by The Good Roads Improvement Company, Cincinnati, Ohio.

treated (using one side of the street at a time), place a sign, "fresh oil," on the barricade, which gives the public fair notice, and then go ahead.

"The best results were obtained when the road was absolutely dry and hot.

"After sweeping the road as clean as possible with a rotary street broom, leaving the sweepings along the edge of the gutter to prevent the oil running on the cement work, the oil was applied over the entire surface and thoroughly spread with brooms, after which the sweepings from the gutter, with sufficient limestone screenings to form a light dressing, were cast over the oiled surface and rolled down with a road roller. The object in using the screenings is to absorb such oil as does not penetrate into the road, and as soon as screenings are applied the work is finished, and no further inconvenience to the public is encountered.

TABLE XI.

COST OF OILING.

"The first application made during May and June, 1907, cost as follows:

Square yards of pavement oiled	375,415
Gallons of oil used	120,477
Total cost on road	$5,559.83
Average gallons per square yard	0.32 gal.
Average cost per square yard	1 48-100 cents

SECOND APPLICATION.

Square yards pavement oiled	635,145
Gallons oil used	156,888
Total cost on road	$5,111.61
Average gallons per square yard	0.247
Average cost per square yard	$0.00805

TOTAL OPERATIONS FOR THE YEAR.

Two applications on 375,415 square yards cost	$8,581.92
One application on 259,730 square yards cost	2,089.52
Total cost for the year	$10,671.44
Total number of square yards oiled (two applications on most of it)	635,145
Equivalent to one application on	1.010,560 sq. yds.
At an average cost per square yard for oiling of	$0.01055

The quality of oil used was a residuum of 20 to 21 gravity, Baumé.

Total amount of oil used, 33 cars, or 277,365 gallons.

Average amount of oil per square yard, 0.274 gallon.

Average price paid for oil on track, $0.0184 per gallon or 77½ cents per barrel of 42 gallons.

"The above record covers all cost of labor, supplies and oil, but does not include the cost of the unloading plant."

Chapter XX.

LATEST VIEWS OF CONGRESS ON ASPHALT SURFACING.

AT the Good Roads Convention, held at Atlantic City, September 25 and 26, 1908, Mr. James E. Owen, M. Am. Soc. C. E., of Montclair, N. J., in speaking on "What a New Jersey Engineer Should Do," said:

"First, we must abandon the idea that it is necessary to have hard roads; secondly, they must be elastic by the interjection of a suitable material; and, thirdly, they must wear but little. The experiments with tar show that a softer stone is better than a hard one. Slag, limestone, granite or trap will be the order of preference. Appreciating this, the careful insistence of selected material, such as trap or granite, which has been our previous practice, need not be made, and the natural local stone or gravel can be made available.

"It seems hard for me, as an engineer who has been giving his lifework to the construction of these so-called hard roads, to take everything back; but with the trend of times and the growth of knowledge, I am convinced that the old practices will pass away and a new era of road construction will come to the fore. This idea dawned on me some years ago, and it is now a conviction.

"Now another and final point—that is maintenance. With an elastic medium in the natural material the wear is almost eliminated; there is no grinding of the surface, no dust and, consequently, no loss. This may seem rather visionary, but two instances in my own knowledge confirm the statement. About eight years ago an asphalt pavement was substituted for a Telford. The travel was so great that four to six inches of stone was ground up in two years. Since the reconstruction, no repairs have been made, and the pavement is in exactly the same perfect condition to-day as when laid. Asphalt, be it understood, is an elastic medium."

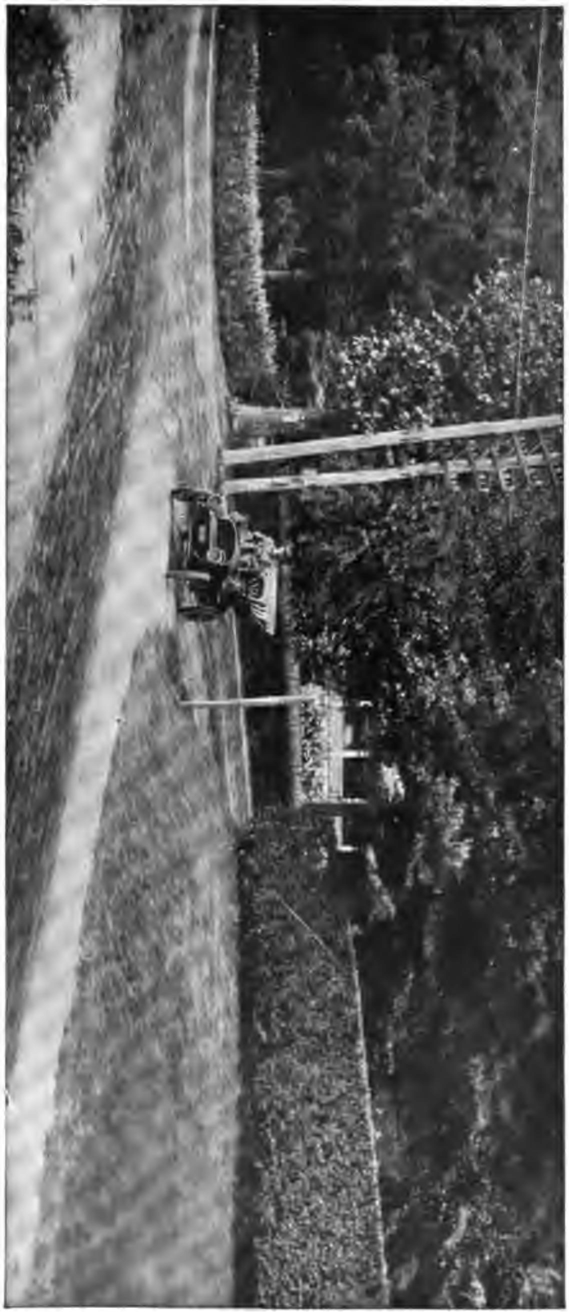
He referred to the very exhaustive experiments made in Rhode Island by Mr. Arthur H. Blanchard, Assoc. M. Am. Soc. C. E., and quoted from his remarks as follows:*

"The conclusions arrived at are these: 'First, that highways subjected to heavy, high-speed motor-car traffic should be built with a bituminous macadam surface, constructed by the mixing method; second, that existing macadam roads subjected to a similar traffic should be reconstructed as bituminous macadam roads, using the penetration method, or, if resurfacing with new road metal is required, by using the mixing method; and, third, that the economical and efficient treatment of macadam roads subjected to a moderate amount of motor-car traffic is at present a matter of conjecture, requiring for elucidation the acquisition of reliable detailed information with reference to the use of the various palliatives now on the market.'"

Among the materials upsed under his supervision was a Texas asphalt. It was purchased from the Texas Company, and cost, delivered at South Ferry, $21.50 per ton of 250 gallons. The cost of the haul from the station to the road, an average distance of 2,000 feet, was $0.10 per barrel of 42 gallons. Therefore the cost of the asphalt on the road was $0.09 per gallon. This asphaltic product is listed by the Texas Company as Texas Asphalt, Grade H. Analyses yields practically no volatile matter to 260° Fahr.; a melting point of 140° Fahr., and only 8.8 gr. per gallons in a water solution.

Mr. George C. Diehl, County Engineer of Buffalo, N. Y., said that asphalt in some form will be the future State road material of the country. Mr. Diehl declared that asphalt, mixed well with stone and other materials, made a durable and elastic road. The author, speaking extemporaneously, said in part: Good roads meant in these days of the automobile, dustless roads, and that at the forthcoming International Congress on Good Roads, to be held in Paris, the vital question in the convention would be the most approved method of surfacing the roads of the world. To his mind there was no uncertainty as to the fact that asphalt in some of its various forms would be the matrix of surface mixtures; the top of the road must be waterproof, in other words—"dustless"—and that object could alone be attttined by the use of asphalt.

*From a paper read before the American Society of Civil Engineers at Denver, Colo., June 25, 1908.



HYDE PARK ROAD, LONG ISLAND.
Treated by The Gulf Refining Company.

He said that for over thirty years he had made the subject of good city streets his study, and that during the administration of the late General Newton, previously Chief of the Engineer Corps of the United States Army, he had been called on to act as special inspector of asphalt pavements, subsequently acting as general inspector of pavements of the City of New York, and so supervised, under the direction of the late D. Lowber Smith, C. E. (Ponts et Chausses, Paris), the varied street pavements then in vogue. These naturally included the Telford-Macadam pavements which at that time—1886, 1887—proved the best pavement for the boulevards in the upper part of the city. To-day these pavements, with an adequate surfacing of two to three inches of asphalt concrete, would afford a durable resiliant waterproof and dustless roadway. As he was not speaking in the interest of any company or asphalt industry, he called attention to the fact that municipal officials could purchase the materials and apply the same themselves. He said that the methods of utilizing asphalt with other materials in the most satisfactory manner could not yet be considered as definitely settled, and that it was engrossing the attention of many able men. Mr. George C. Clausen, of the Sicilian Asphalt Paving Company, two years ago, had laid experimental strips in Bronx Park, New York, and this year was supervising the construction of a large stretch of roadway in that park, using the "Sicilian asphalto," and guaranteeing same for five years. He called the attention of the convention to the fact that many of the delegates would, within a few days, be going over the race course laid out by the Automobile Club for the race to be held on the 225th anniversary of the founding of their neighboring "City of Brotherly Love," and that they would pass over a section of road treated with "asphalithic" surface, laid at the intersection of Belmont Avenue and the city line, by the Filbert Paving and Construction Company, of Philadelphia. He said that he had on the previous day called on Mr. J. L. Rake, the general agent of the Barber Asphalt Paving Company, who had informed him that his company was deeply interested in the subject of dustless roads, and had laid asphalt concrete in a number of cities and towns; their expert, Professor Clifford Richardson, who had complete charge of the laying of the experimental roadways, as one of the representatives of the United States government, and additionally as the representatives of the States of New York and the Amer-

ican Society of Civil Engineers, had just sailed for Paris to attend the International Congress, and so could not be present at this convention. The speaker said that he himself had a number of experimental pavements under way, and that in view of the remarks of Mr. Beemer, the Deputy State Highway Commissioner of Pennsylvania, on the scarcity of broken stone in his State, he would add that he had arranged for an experimental pavement to be laid with asphalt and slag. He had hoped to have had an oportunity of asking Dr. Cushman, while on the platform, of the latest results of the United States government investigations on this method of construction. He said that contrary to the condition of affairs in the past century, this country was not now dependent on sources of supply from Europe, the West Indies or South America, and that the United States could now produce all the bitumens necessary for the boundless calls the future would necessitate for furnishing asphalt concrete. He said that a great many of our States could furnish liquid maltha or asphalt which could be refined to any consistency required, enumerating California, Texas, Indiana, Kansas, Kentucky, Ohio, Pennsylvania and possibly New York. He claimed that any oil with an asphaltine and petroline base could be refined to yield a satisfactory paving material, but that parafine base oil must be studiously avoided. In the discussion that followed the delivery of the address, Mr. Beemer said he doubted whether Pennsylvania produced a petroline base oil, and the speaker promised to make definite investigations on the question. A delegate objected that the author had not dwelt upon the subject of the necessary foundation, and the latter replied that he was addressing himself principally to engineers and public officials, who realized fully that a solid foundation was the prerequisite for any well-paved street or road. In reply to the question of cost of the asphalt concrete two-inch surface, the speaker stated that it would mean an additional expense of not over twenty cents per square yard above the cost of an ordinarily constructed macadam road.

On his way to attend the First International Congress of Road Builders, held in Paris, Mr. Samuel Hill, of Seattle, Wash., who has given many years of his life, and many dollars from his purse to foster the idea of macadamizing the roads of the United States, and particularly of his home State, was accompanied by two other delegates, Mr. R. H. Thompson, city engineer, of Seattle, and Mr.

DETAIL OF SPRINKLER ATTACHMENT FOR OILING.
W. H. Dunn, Superintendent of Parks, Kansas City, Mo.

Samuel C. Lancaster, Professor of Good Roads in the Washington State University.

Mr. Hill, who is president of the Washington Good Roads Association, said: "Many delegates from every State in the Union were to attend the congress, Mr. Parker, president of the Massachusetts Highway Commission, and Mr. Fletcher, secretary of the commission, being among the number.

"There is little use of my reciting the history of road building to you," said Mr. Hill, to a New York Herald reporter, "how it began with the Romans, how Napolean carried the matter along and all that, but I do want to say that France led the world in road building until a few years ago, when its highways began to deteriorate, and that is the primary reason for the coming congress. In England there came the Telford process of road construction, and the Macadam, which, however, is totally different from what we understand by that term to-day. But, on a broad plane, I should say that the Macadam process carries out the theory of building a tight roof over a dry cellar.

"I take it that the building of good roads is the most important question that confronts the American people to-day. Every man, woman and child must use the highways at some time, whether afoot, on horseback, in a road wagon or in automobiles. The first man to call attention to the need of good public roads was A. J. Cassatt, now dead, and he was followed by James H. McDonald, of Connecticut, who is president of the American Road Makers' Association. Understand at the outset, please, that this work of ours is only for the betterment of the country and that no man who has given time and thought to the project has done other than to put out money from his own pocket, with no hope of ever getting it back, much less of viewing it as an investment.

"Of the men who are to accompany me as delegates to the congress from Washington Mr. Thompson is one of the ablest of municipal engineers, and it was he who recognized the fact that, in the building of asphaltum roads any material having more than three per cent of fixed carbon would be injurious. His ideas were put into operation, each consignment of asphaltum was tested.

"Mr. Lancaster has the chair in the department of Good Roads in the Washington State University, the first institution to establish such a course. It is a popular one, too. It had one hundred and twenty-five students in 1907, and this year it began with no less than

two hundred men in the class. We think in Washington that we have the best laws in the world as far as the making of good roads is concerned, for they have been compiled with the greatest care. Mr. Lancaster is carrying on a great educational work. We have organized bureaus for the dissemination of information about the State roads, and have opened a schoolhouse campaign where lectures are held and photographs and lantern slides showing the highways throughout the State and those in foreign countries, which I have gathered in my many journeys, are shown to those who attend.

"When I became interested actively in the subject, about four years ago, I made up my mind that I would ascertain just what it cost one of our farmers to haul along the roads for one mile garden truck and other material weighing one ton. For on the farmer principally falls the burden of our bad roads. I learned that because of the poor roads the United States lost, with the setting of the sun every day, nearly $3,000,000 which might be saved were the roads in proper condition. Just think of that! And yet not a cent has come from the federal administration for the betterment of these roads. Some States, as Washington, and a few others, have appropriations, but not in proportion to the calling necessity. Then we began to get busy in our State of Washington.

"We put the convicts at work and we found the process was a great success. Each convict netted to the State $4.03 for each day of work, which amounted to something. And not one convict turned out to this task tried to escape. North Carolina led in this system of convict labor, and that was fifteen years ago, and now it has eighteen hundred miles of macadamized roads built by convict labor, and only two per cent. of the men employed in this way tried to escape. In Washington the majority of our roads are constructed over mountains and at a maximum grade of five per cent. This convict labor did not interfere with union labor, either, for with the construction of the roads there was more work for the union men in other branches of the task.

"Let me tell you of our method in Washington. We build our roads usually about one hundred feet wide. First we have in the middle a strip about sixteen feet wide. On the bottom we take from the screen cubes of rock about two and a half inches. This rock is put down wet, and a ten-ton steam roller goes over it from the sides, to make it cement and rise high in the middle. Then comes rock one-half the size of the other, and then the rock three-quarter

OILING HARRISON BOULEVARD, KANSAS CITY, MO.
Treated with Kansas Asphaltic Oil. W. H. Dunn, Superintendent of Parks.

inch cubes. Over this is poured asphalt, melted to about one hundred and eighty to two hundred degrees Fahrenheit, and over all this is thrown the fine pebbles. Then the steamroller gets to work again. Parallel to this strip we make a path of light material, designed for horses and vehicles; alongside that comes a bridle path, for equestrians only, and then comes another strip of grassy lawn, with flowers and trees. We maintain that strip in all strictness.

"In contrast with this let me tell you that in the Bois de Boulogne, in Paris, a road was put down last year, and that now it is full of holes and worthless, and that the automobiles which passed along it raised such clouds of dust that the grass disappeared and four trees which for years had been the pride of Parisians were killed. The Chief Road Engineer of Paris has told this to us in a report and he has asked the visitors to the congress to view this worthless road.

CHAPTER XXI.

MUNICIPAL ASPHALT PLANTS.

THERE are today in America Municipal plants operated in the following cities: Winnipeg, Man.; Columbus, O.; Dayton, O.; Toledo, O.; New Orleans, La.; Toronto, Ontario; Detroit, Mich.; Allegheny, Pa.; Omaha, Neb.; and Seattle, Wash., has lately contracted for the erection of a plant.. In the October, 1908, issue of the "Municipal Engineering" the following interesting data was given by that magazine, which for so many years has given the closest attention to matters pertaining to the asphalt industries

It is said that the number of municipal repair plants is increasing gradually and a few of them have now been in use long enough to give some idea of the cost of operating them so that at least a preliminary comparison can be made with the contract system still in use in most cities. Such plants as those at Columbus, O., and Indianapolis, Ind., have not been in operation long enough to give more than a daily force and material account and the actual effect of idle time, accidents, depreciation, repairs, etc., cannot be given exactly. The figures from them will be given more fully when more reliable statements can be made.

Under the contract system in some cities the price bid is per square yard of pavement replaced. The prices vary greatly, being $1.65 in Minneapolis and St. Paul; $1.50 in Utica, N. Y.; about $1.35 in Indianapolis in 1906; $1.35 to $1.50 in Columbus, O.; $1.75 in 1897 in Rochester, N. Y., reducing gradually each year to $1.27 in recent years; $1.23 to 74 cents in Buffalo, N. Y.; 89 cents in Toronto, Ont.; 66 cents in Indianapolis in 1907. The last named contract was the cause of much scandal on account of an alleged attempt to make up for the low price by over-measurements of areas of work done.

Other contracts are per cubic foot of material placed, measurements being taken at the plant as the wagons are loaded. Under the contract system Brooklyn, N. Y., paid in 1905 67 cents per cubic foot for wearing surface and 25 cents per cubic foot for

SPIKING UP OLD ROADWAY.

SAME ROADWAY ONE DAY LATER.
The Kelly-Springfield Road Roller used.

binder. Washington, D. C., paid 49 and 25 cents, respectively. A compression of one-sixth in laying makes the cost of the asphalt wearing surface in place in the pavement 78 cents per cubic foot in Brooklyn and 57 cents in Washington.

The cost of laying asphalt in repairs by the Brooklyn municipal asphalt repair plant, which went into operation in June, 1907, has been 85.19 cents per cubic foot of wearing surface and 74.46 cents per cubic foot of binder. These figures include materials, labor, transportation, supervision, fixed charges, maintenance and operation of plant machinery and tools. If the thickness of the wearing surface is assumed at 2 inches, as in New Orleans, the cost of wearing surface per square yard becomes $1.28.

It is not easy to reduce the reported costs of running the New Orleans municipal asphalt repair plant to the same basis as the figures given above on account of numerous differences in conditions; for example, absence of binder and greater thickness of wearing surface. The plant was used for laying new asphalt pavements as well as for repairing old pavements. Material and labor costs were kept separately, special charges against the asphalt plant as a whole were divided equally between the new and repair work and general charges against the paving and repair department were divided among the three sections, new, repair and miscellaneous work, 35 per cent. going to the repair section. The "naphtha coat" was laid under about two-thirds the asphalt wearing surface deposited, and new concrete was put under about one-eighth of it. Deducting the cost of the concrete at 87 cents a square yard, the figure derived from the data regarding the work, the remainder will give the combined cost of naphtha coat and wearing surface for all the repairs made. This cost averages $1.03 a square yard, and does not include depreciation and interest on cost of plant, which may amount to 15 cents a square yard, making a total of $1.18. It is quite possible that this figure is too high, for new pavements, deducting cost of grading and concrete foundations, seem to have cost only 63 cents a square yard for the naphtha coat and asphalt wearing surface, as compared with $1.03 above. Repair work is more expensive than new work, but this difference of 40 cents seems to be excessive and may be due to errors in either or both items made in the rather complicated distribution of costs.

The first season of the Columbus, O., repair plant has not yet ended, but the operators of the plant have been obliged to fix a

price for work done for other persons than the city and have set $1.25 a square yard as a price for such work, which, including all general and special items, plant and fixed charges, as well as maintenance and operation, will cover the actual cost with as little margin as is safe in the absence of full data.

Various reports from the Detroit, Mich., plant have shown 83.6 cents per square yard cost of materials and labor and $1.05 including all items of cost.

In Allegheny, Pa., one report shows 75 cents a square yard as the cost of asphalt repairs for material and labor.

An unofficial report from Dayton, O., indicates a cost of 57 cents a square yard, which probably includes only materials and labor.

The average cost in the Montreal municipal asphalt plant is $1.22 a square yard, including all work in connection with the repair.

The Winnipeg municipal asphalt plant keeps detailed records of the work done. Records of laying new pavements are at hand. Deducting from the total cost for new pavements the cost of grading, sand foundation, concrete and binder, and 40 per cent. of the general charges, leaves the cost of laying the wearing surface 87 cents per square yard. This is doubtless somewhat less than the cost of laying the same area of repair work.

Allowing for the difference in conditions in these various cities it is fair to fix on about 85 to 90 cents per square yard as the average cost of laying repair work for materials and labor, and say $1.15 to $1.25, including all charges in municipal plants. Cost of the various materials and of labor and the weather conditions produce variations each way from these averages.

Cities letting their asphalt repairs by contract have considered prices fair when they range from $1.25 to $1.50, according to locality. The difference indicates the cash saving to the street repair departments.

Several cities have installed plants for doing their own asphalt repair work, not so much because they expected a reduction in the cost of the work, as for the purpose of securing complete control of the kinds and qualities of materials to be used and time of making repairs. In these respects the cities have found the results very satisfactory, enough so to warrant some increase in cost. However,

USING ASPHALT BITOSE FILLER IN CENTRE MARKET, BALTIMORE, MD.
Bitose Filler supplied by The Ellis Company, Baltimore.

as the above figures will show, a reduction in cost has also resulted in nearly every case.

Contractors for asphalt work express themselves frequently as being greatly pleased with the results from the municipal asphalt repair plants. They are usually able to induce the municipal plant to do repair work and small jobs at a reasonable price, which, while greater than the cost to them if their plant is running, saves them much expense if the plant must be started up for a small amount of work or particularly if a plant must be moved in from some other city. The city's street repair department is more than satisfied because it has complete control of the materials and workmanship and can thus insure good work done at the right time.

Chapter XXII.

ASPHALT WATERPROOFING.

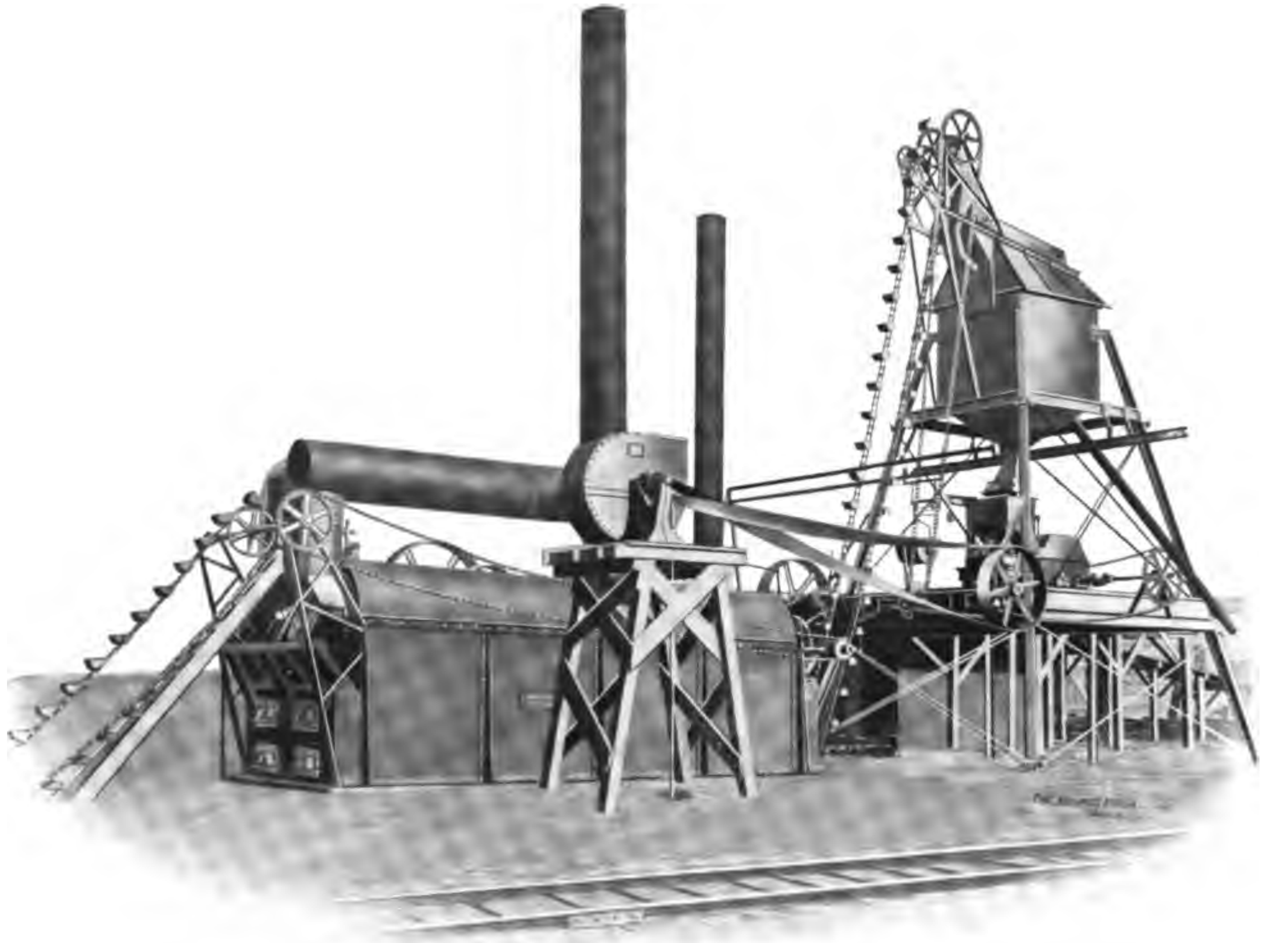
THE extent to which asphalt enters into waterproofing construction can be imagined when it is seen that the Sicilian Asphalt Paving Co. in the New York Rapid Transit Subway, the Penna. R. R. Terminals and Tunnels in New York and New Jersey, the N. Y. Central and H. R. R. R. Terminals and Improvements in New York and the Sixth Ave. Subway of the Hudson R. Tunnel system laid over 20,000,000 square feet of waterproofing.

The author has taken advantage of the courtesy of Mr. A. M. Tipper, of the Texas Co., and gives in full a paper* prepared by him dealing comprehensively with the subject of waterproofing. Mr. Tipper says that "the last ten years have witnessed a rapid increase in the field of cement usefulness. The formative character of concrete and the ease with which it is adapted to a continually enlarging number of structures have brought the concrete engineer in immediate touch with problems connected therewith which for years were largely—if not entirely—ignored.

"The experiences of concrete engineers and contractors in their progress with the application of concrete to structure building of all kinds have shown them that in the practical field work, under the conditions oftentimes inevitable, with the natural imperfections which attend any work conducted in the mass, have proved to them that for many purposes to which concrete is at present applied it is necessary to protect the concrete structure and to prevent percolation through it. These experiences have also shown the architect and engineer that the field of cement usefulness would be greatly enlarged if there is supplied a perfect method of protection and waterproofing.

"For this reason the waterproofing problem is at the present time attracting the attention of all architects and engineers; and on account of its importance in the increasing application of cement of

*A paper read by Mr. A. M. Tipper before the Cement Products' Exhibition Co., December, 1907.



A SEMI-PORTABLE ASPHALT PLANT DESIGNED FOR MUNICIPAL REPAIR PLANT AND GENERAL CONTRACTORS' USE.

great interest to the cement manufacturers, while to the cement users the importance of the problem cannot be overestimated. The action of railroad companies, large construction companies and others in their investigation of waterproofing is evidence of the interest displayed in this subject and the necessity of adoption of waterproofing for the protection of the concrete structure. It may be said, in fact, that this protection is the necessary requirement for the consideration of concrete work as permanent. Climate conditions, atmospheric impurities, etc., may aid disintegration. Many propositions have been brought forward with the object of waterproofing in all kinds of ways by different methods, frequently with the result of disgusting the engineer with futile attempts at solving his problem or with dismay at the cost.

"A large amount of the trouble experienced in the satisfactory waterproofing of concrete, and the consequent costly and inconvenient experiments, have been the direct result of a want of knowledge of the application suited to the local conditions which obtain in the structure to which the waterproofing is to be applied, a want of consideration of the requirements of waterproofing or a total disregard to the relative cost which the protection should bear.

"Out of this mass of experiments and gradual formation of satisfactory waterproofing propositions has come the belief that the most satisfactory method of waterproofing concrete structures under all irdonary conditions, the most inexpensive and the most extensive in its possible applications is by the application of a bituminous coating on the surface of the concrete. It raises no question as to possible deleterious effects upon the concrete as do the compounds which enter the concrete mix, these being the subject of considerable disagreement among engineering chemists as to their ultimate effect upon the concrete mass.

"The application of the bituminous coat upon the concrete surface is a very simple, inexpensive proposition, readily handled with unskilled labor after a little training and satisfactory in its results.

"Much poor waterproofing has been done in the past with so-called bituminous products of all kinds, and much distrust has fallen upon the method by reason thereof, either from a want of knowledge of the material or a want of consideration of the effect of its use. For a considerable period coal tar products were used in this connection and at the present time are still occasionally used. The properties and composition of coal tar products make them thor-

oughly unsatisfactory as a waterproofing. They neither hold their ductility nor pliability, becoming brittle at comparatively high temperatures and soft at comparatively low temperatures, quickly losing the small bonding and elastic qualities they possess, and in a short time becoming absolutely worthless.

"The first requirement of waterproofing covering for concrete is that it shall be impervious to water, and here the necessity of pure asphaltic bitumen for the purpose is thoroughly illustrated. Samples of two different kinds of asphalt taken and held in water for over one year at a pressure of 150 pounds to the square inch showed that one of these samples had absorbed no moisture, while the other had increased more than 129 per cent. in weight, owing to the absorption of water. Both of these asphalts claimed to be pure material and were guaranteed as such, yet evidently the one product was waterproof, while the other, without some readjusting, was decidedly porous. Pure asphaltic bitumen, that is, with over 99 per cent. pure bitumen in its composition, should show no absorption of moisture at all, presenting an absolutely impermeable surface. A further important requirement in bituminous waterproofing is its range of ductility, and here it is necessary to state that the fact that the product presented for waterproofing is pure bitumen does not necessarily include a high range of ductility or a particularly brittle point. The proportions of the petrolenes and asphaltenes composing the bitumen may vary, in which case the brittle point and range of ductility may vary. It is therefore essential for the protection of the user that the range of ductility be asked for.

"It is necessary that the bitumen be of sufficiently high melting point to insure its remaining solid under any of the conditions of its work, and it is just as imperative that it should remain pliable under any of the conditions. This makes it evident that the waterproofer should be conversant with the local conditions of the work his material will be against on any particular proposition.

"In one test asked for the waterprofing was spread one-fourth inch thick on burlap, placed against a strong grating arranged in a testing machine provided with a pump for pumping ice water, in which was floating crushed ice. The specifications called for the waterproofing material withstanding a pressure of 10 pounds without the coating becoming brittle and cracking or passing water and that it should not melt below 225 degrees Fahrenheit. All samples

MERRIAM PATENT ONE CAR ASPHALT PLANT.
Manufactured by The East Iron & Machine Co., Lima, O.

but one broke at seven pounds. The successful sample stood 10 pounds pressure, which was then continued for twenty-four hours, at the end of which time it showed no defect. It was then determined to conduct a breakdown test, which resulted in the sample withstanding a pressure of 300 pounds, when the packing blew, but the waterproofing still remained intact.

"The waterproofing bitumen must therefore be pure and have a long range of ductility, and as an important corollary the waterproofing manufacturer must be able to suit his material and application to local circumstances and conditions.

"It is very evident that to provide a waterproof floor for a warehouse where there is heavy trucking, etc., over it, is a different proposition from waterproofing a bridge floor, and it is equally as evident that the method of application in the case of the railroad bridge, where the headroom between floor and rail is small is a totally different proposition from the bridge, where the headroom is 14 to 20 feet.

"Briefly, the ordinary method of waterproofing by using a bituminous coating and the one used under a number of conditions is by the application of a priming coat of paint, which has light enough body to enter the pores of the concrete and form an anchorage for the heavier bituminous coat. On top of this is mopped a hot coat of pure bitumen. This coat is of varying thickness, according to the work, from one-sixteenth of an inch on a concrete roof to one-fourth or one-half inch for bridge floors and deep foundations. Where the coating is exposed to the effect of cutting or chipping some reinforcement through the coat or some hard mastic mix is necessary. For vertical structures where the cutting effect is not accompanied by heavy load the reinforcement of the coating by the application of a single ply burlap is sufficient. Where, however, the waterprofing is horizontal and there is a cutting load above, it is often advisable to use a mastic mix.

"The following specifications for the asphalt will insure good material for this work:

"Asphalt shall be used which is of the best grade, free from coal tar or any of its products, and which will not volatilize more than one-half of 1 per cent. under a temperature of 300 degrees Fahrenheit for ten hours.

"For metallic structures exposed to the direct rays of the sun, the asphalt should not flow under 212 degrees Fahrenheit and

should not brittle at 15 degrees below freezing Fahrenheit when spread thin on glass.

"For structures underground, such as masonry arches, abutments, retaining walls, foundation walls of buildings, subways, etc., a flow point of 185 degrees Fahrenheit and a brittle point of zero Fahrenheit will be required.

"The asphalt covering must not perceptibly indent, when at a temperature of 130 degrees Fahrenheit, under a load at the rate of 15 pounds per square inch, and it must remain ductile at a temperature of 15 degrees below freezing Fahrenheit on metal structures, and at zero Fahrenheit on masonry structures under ground.

"In the application of coatings requiring a hard surface the finishing coat should be sprinkled with a layer of hot washed roofing gravel torpedo sand or slag to provide a hard surface. If this hard-surfaced waterproofing is required of considerable thickness, the asphaltic concrete of asphalt mastic and grit is the best method of waterproofing.

"Asphalt is undoubtedly the oldest waterproofing known and was used centuries before the Christian era began. It has proved itself a thoroughly satisfactory coating, taking care of the expansion and contraction, and providing a pliable and ductile waterproofing, sealing up the pores in the concrete, covering hair cracks and checks, retaining its qualities for many years without deterioration.

"Its insulating qualities increase its value in an age when concrete and steel structures are being continually used in places where the mtal may be subjected to electrolitic action."

"CALLENDRITE"—(Callender's Pure Trinidad Lake Bitumen Sheeting) is extensively used on

WATERWORKS—For lining open and covered storage and service reservoirs, filter beds, valve towers, aqueducts, &c.

Old leaking reservoirs or filter beds can be made absolutely watertight by its use.

ON ROADS—For covering bridges, viaducts and arches, lining subways; also for girder seatings.

ON SEWERAGE WORKS—For lining settling and filtering tanks, culverts and conduits, sewers, &c.

ON GAS WORKS—For lining gas holder tanks, &c.

IN MINING AND COLLIERY WORKS—For lining pit ponds, tanks, storage and condensing reservoirs, &c.

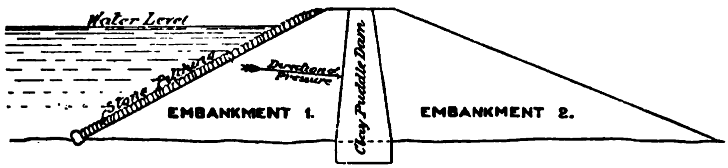
WATERPROOFING 125 FEET BELOW WATER LEVEL. GANG OF WATERPROOFERS READY TO DESCEND CAISSON NO. 2, PENNSYLVANIA RAILROAD COMPANY.

All subaqueous waterproofing of Pennsylvania Railroad Company in New York City done by Union Construction & Waterproofing Company, under direction of Alfred Noble, Esq., Chief Engineer.

IN ELECTRICITY WORKS—For lining cooling ponds, transformer chambers, cable subways, dynamo bed foundations, &c.

IN COLD STORAGE CONSTRUCTION—For lining chambers for insulating purposes, &c.

The advantages of using "Callendrite" for making watertight the earthwork embankments of open storage and service reservoirs will be apparent to the engineer, both from an economic and a structural point of view.



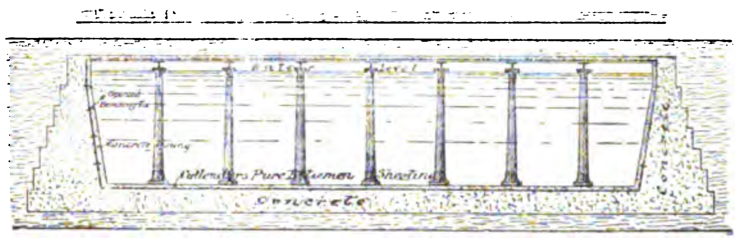
The sketch A, which is a section of an ordinary earthwork embankment with a clay puddle core, shows that the water will reach the face of the puddle before it meets with resistance; so that, in spite of the existence of the inner bank (1), the only effective resistance to the pressure of the water is afforded by outside bank (2) Should the puddle get damaged, either by settlement or by the depredation of rats or other vermin, the efficiency of the reservoir is destroyed. The arrow on the sketch shows the direction of the pressure of the water.

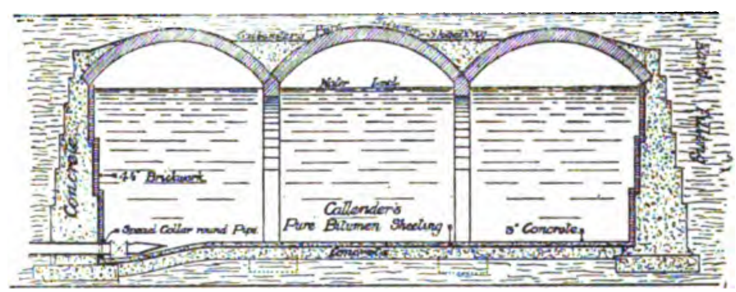
If the same reservoir were constructed with "Callendrite" as shown in Sketch B, it will be seen that, whereas in the former case

SKETCH B.

only one-half of the embankment offers effectual resistance to the thrust of the water, in Sketch B the whole of the embankment is brought into action. In addition to this, the direction of the thrust, as shown by the arrow, is such as to render the structure more stable, as it now has less tendency to overthrow the embankment

or to make it slide, and at the same time tends to make the embankment more homogeneous and to bind it closer to the ground at its base. Therefore, when Callender's Sheeting is employed, it is evident that the section of the embankment can be considerably modified, and a large reduction obtained in materials and cost. The saving in materials is especialy important in situations where the amount of excavation is small and the expense of procuring suitable





material for constructing the embankment consequently forms an important factor in the total cost.

Where "Callendrite" is used, it is only necessary to line the inner slopes of the embankments and the floor of the reservoir with a thin layer of concrete, so as to form an even surface for the sheeting, and then to cover the latter with 3 inches of concrete as a protection from mechanical damage The thin layer of concrete covering the sheeting which lines the inner slope of the embankment is prevented from slipping by the construction of a concrete toe at the foot of the slope, as shown in Sketch B, which at the same time prevents any tendency of the inner section of the bank to slip or spread. In short, the use of 'C'allendrite" not only renders storage and service reservoirs absolutely watertight, but secures perfect solidity and great economy in their construction.

FIVE-TRACK VIADUCT, ONTARIO & WESTERN RAILROAD, AT OSWEGO.
Resting on Rock Asphalt Mastic, waterproof foundation, over buckle plates. Done by The Union Construction & Waterproofing Company, under U. S. Government supervision and C. E. Knickerbocker, Chief Engineer.

In the construction of covered service reservoirs "Callendrite" is very serviceable, as its employment as a lining entirely dispenses with the necessity of costly outside trenches filled with clay puddle. As will be seen by the accompanying sketches, the main walls can be built in concrete, the sheeting being applied to the inner face and supported by an inner lining of 4½-in. brickwork or 6-in. of fine concrete. The bitumen sheeting covering the floor of the reservoir, which is continuous with the sheeting lining the walls, is protected by 3 inches of fine concrete, by a course of brick on edge, or by paving stones, according to the requirements of the case

Realizing that felt did not render a sufficiently strong fabric for waterproofing, Mr. H. R. Wardell, of the Barber Asphalt Paving Co., on a visit to Germany obtained the idea of what he considered a possible improvement on Callendrite and his company are manufacturing the Positive Seal Fabric, which is a saturated and coated burlap. This material is used in connection with Positive Seal Liquid or Solid Cement, as the case demands, in layers or plies. It is strong and resilient. It will give and twist, bulge, expand or contract, but never break, and so long as it does not break it will positively seal against water. This fabric has a much greater tensile strength than any felt made. For waterproofing, roofing or dampcoursing specify the construction the same as when using felt, except one-half the number of plies to get the same results. It is supplied in rolls of 300 square feet.

CHAPTER XXIII.

ASPHALTS IN ROOFING.

OVER thirty years ago the author had a year's experience with the Warrens, who, at that time, had just started the use of asphalt in place of coal tar residuum for asphalt roofs, and with interest he now recalls his visits, in company of the late Samuel M. Warren, to architects' offices when they carried with them a segar box containing a little alcohol cooking machine with which they gave practical demonstrations of how the volatile oil of coal tar pitch evaporated and left dust, while the asphalt retained its elasticity and body under similar heat. The Warrens manufactured their asphalt felts at Sixth street, Long Island City, and on the south side of Seventh street the author, in conjunction with the late Edwin H. Wootton, built in 1892 the New York Mastic Works for the Compagnie Generale des Asphaltes de France, the sites of which are now owned by the Val de Travers Asphalte Paving Co., of London, and the Cyrus Warren Estate.

Mr. Samuel M. Warren in 1845 was engaged in the business of laying pine tar roofs, and coal tars at that time were the waste products of the gas works. He conceived the idea of using coal tars to mix with pine tar pitches, and almost immediately thereafter used coal tar for saturing dry felt in making roofing paper. The first experiments and use occurred in Cincinnati. Mr. Warren was then a young man, and the opportunities for the development seemed so great that his brothers, John Warren, Cyrus M. Warren, Herbert M. Warren and E. Burgess Warren, successfully and almost immediately enteeed with their brother upon contracting systematically for the largest supplies of tars in the United States. The various brothers controlled at one time the tars produced in Cincinnati, St. Louis, New York City, Philadelphia, Baltimore and Washington, D. C.

John Warren, who located in Buffalo, N. Y., is entitled to the credit for first distilling coal tar and making coal tar pitch; and its immediate substitution for pine tar spread over the United

NEW YORK CUSTOM HOUSE.
The bituminous roofing in this building is Genasco Brand Trinidad Lake Asphalt, furnished by The Barber Asphalt Paving Company.

States. Hendricks' Architectural Engineering and Mechanical Directory of the United States gives names and addresses of over seven thousand concerns now actively engaged in the laying of this kind of roofing. The business was almost immediately so prosperous that out of the revenues Mesrs. Cyrus M. Warren and Samuel M. Warren took courses in Harvard College, the latter afterward being professor of organic chemistry in the Massachusetts Institute of Technology and the author of that part of Dana's work on hydrocarbons which appeared in Dana's work on mineralogy.

When petroleum came on the market the Warrens were among the first distillers in the United States, and Mr. Cyrus M. Warren became recognized as the best authority on the use of bituminous materials, and invented the process of fractional distillation of petroleum and coal tar oils, which process has given to the world all the numerous by-products. The commercial growth of the business up to 1870 was phenomenal, and all of the best energies were necessarily applied to the commercial development rather than to scientific investigation. In 1870 reverses came and found the Warrens with large contracts for tar, with a falling market and increased competition in the price of tar and manufactured goods.

At this time competition made necessary the development of something new and better, and Cyrus M. Warren invented the asphalt roofing which has so long been manufactured by the Warren Chemical and Manufacturing Company, and they became the first large importers and refiners of asphalt in this country.

The early failure of the coal tar bitumens in concrete construction, owing to the price at which they were laid, furnished no incentive for development, and a general view prevailed that concretes in which coal tar bitumens were used were deficient in every respect and should be excluded from all standard specifications. A monopoly in the control of asphalt made it commercially profitable to decry even the best coal tar bitumens and to extend the use of asphalts. Yet it seems to be a fact that the early asphalt pavements were as great a failure as the early coal tar pavements.

In recent years the Warrens have played a prominent part in the development of the asphalt pavements of the country. Mr. E. Burgess Warren was one of the organizers and one of the largest stockholders of the Barber Asphalt Paving Company, and for many years its vice-president. Cyrus M. Warren was the organizer and the president of the Warren-Scharf Asphalt Paving Company, and

in the management of this company and of the Warren Chemical and Manufacturing Company and other allied interests he was aided by his brothers, sons and nephews, and there have been engaged in the business over twenty-two Warrens, but today no member of the family is interested in the roofing business.

One of the pioneers of the prepared roofing business is the Stowell Manufacturing Company, who, in the manufacture, unite the skill and experience developed by years of constant and careful attention devoted to the manufacture of asphalt roofings, exclusively, with the highest quality of raw materials available, without regard to their cost.

The best quality of fibrous pure wool felt is saturated with genuine Trinidad Lake Asphalt and heavily coated with the same material of a stiffer consistency and into which is firmly imbedded a dense surfacing of crushed granite, felspar, ground asbestos fibre, cork, gravel, sand or ground mica nad slate.

They produce ten varieties of surfaced roofings as well as several thicknesses of saturated roofing felts of one, two and three ply.

Among these varieties of surfaced roofings are found those suitable for any class or style of buildings as roofing, sheathing or exterior surfacings.

These products are made from natural Trinidad Asphalt exclusively, and no coal tar or coal tar products whatsoever are used. As a result these felts do not dry out or become stiff or brittle. On the contrary they are flexible and tough, yielding readily, and without injury, to contraction and expansion.

This line of surfaced goods affords successful resistance against the action of weather, acids and gaseous vapors, as well as against ignition from flying firebrands, or burning cinders. They remain in good condition in any climate on flat or pitched roof or if applied to the perpendicular sides of buildings.

Asphalts are used for "prepared" or "ready" roofings by a number of companies and under an endless variety of brands, following the name of "Ruberoid," manufactured by the Standard Paint Company, a prolific list of roofings has been put on the market ending with "oid." The "Paroid" is a well known brand in which asphalt is partially used, and the "Flintkote," manufactured at Rutherford, N. J., by the Flintkote Manufacturing Company, is made with pure asphalts. The Trinidad Asphalt Manufacturing Company, of St. Louis, Mo., among its manufactures includes Rub-

SINGER BUILDING.
Hetzel's Rubber Roof Cement used in this building; supplied by J. G. Hetzel Estate, Newark, N. J.

bero. Among other users of asphalt for their roofings are the Barber Asphalt Paving Company, who make the "Genasco" brands; the Lincoln Waterproofing Company, of Bound Brook, N. J.; the National Roofing Company, of Tonawanda, N. Y., and several Western concerns. Malthoid, originally manufactured in California, is now also made in New Jersey by the Standard Paint Company. The Johns-Manville Company also use large quantities of asphalt in connection with their roofing materials. The efforts made by the Warrens to extend the use of asphalt for graveled surfaced roofs has not been sustained of late, but in cases of high-class work such as the New York Custom House and generally for United States Government work genuine asphalt is called for under a vitrified brick tile surface.

The rock asphalt roofs so extensively used in Europe seem to have gone out of vogue in the United States, and in these days of roof gardens, it is, of course, necessary to have a roof not dented by chairs, &c. It is probable that reduction in cost of the native asphalts will cause a return to its use for ordinary graveled or slag roofings, as the cost will now compare favorably with what have lately been considered cheaper pitches. An ordinary slag surface specification would read about as follows:

STANDARD TILE ROOFING.

Specification.

The grade of the roof, which should be at least one-fourth inch to one foot, should be formed by the mason, and the surface of the concrete finished smooth and hard by him before the roofer begins. The roofer should coat the surface of the concrete with hot asphalt cement in quantity sufficient to completely cover the same; over which lay five thicknesses of best quality asphalt roofing felt. The felt to be laid shingle fashion—beginning at the lowest point, with all laps stuck for at least two-thirds of their width with hot asphalt. Metal flashings shall extend out on this felt for four inches, and the roofer shall cover them with two felt strips securely cemented in place with hot asphalt. The entire exposed surface of the felt to be then coated wit hhot pitch, over which lay 6x9x1-inch vitrified roofing tiles.

Tiles to be laid in one inch of cement mortar—composed of one part of Portland cement (or equal) to three parts sand. Tiles to

be laid true to grade, joints broken, and the roof finished by grouting joints with liquid grout composed of one part each of sand and cement.

ASPHALT SLAG ROOFING.

SPECIFICATION.

On fireproof construction the surface of the concrete should first be coated with hot asphalt, in quantity sufficient to completely cover the same, then proceed as over wooden construction.

On wooden construction the roof boards should be smooth, solid and laid closely together. Commence at eaves or gutter and lay full four thicknesses of best asphalt roofing felt, the felt to be laid shingle fashion, with one-fourth the width of each lap exposed. Securely nail on back of each sheet with nails and tin caps. All laps to be thoroughly stuck for at least two-thirds of their width with natural Asphalt Roofing Cement, applied hot. The entire surface of the felt then to be coated with the same material, into which shall be bedded clean, dry roofing slag.

Ten gallons of asphalt and three hundred pounds of slag to be used on each one hundred square feet of surface.

TOWER FOR SEMI-PORTABLE ASPHALT PLANT.

Chapter XXIV.

ASPHALT FOR MANUFACTURE.

THE uses to which asphalt may be applied as an ingredient in manufactures are multitudinous, and the author cannot pretend to enumerate them. Photography, ink manufacture and endless industries call for the use of this material to a greater or less extent.

Mr. John A. Yates, a prominent civil engineer, who was in charge of the building of the forts at Fort Wadsworth during the Spanish-American war, said that it is a recognized fact that asphalt is such a thorough waterproof and insulating material that the Insulatine Company of New York are using it in considerable quantities in the manufacture of their insulating and electrical cements.

Mr. David Szende, Director of the Hungarian Asphalt Company, Budapest, while on a visit to New York about five years ago, gave the author some information on the making of varnish from Derna asphalt which may be interesting. The Derna asphalt is a high-class bitumen extracted from bituminous sandstone very similar to that found in the Indian Reservation.

Take a quantity of the Derna mineral, and after breaking it into pieces as large a fist, put it into an open iron or copper boiler, which should be previously cleaned, especially from any greasy or fatty substances. A good fire will soon melt the material, which will become quite liquid by being stirred occasionally. It is advantageous when once liquid to let it boil for 2 or 3 hours without stirring, merely skimming it from time to time. In this warm state it should be put into a clean vessel and an equal weight of turpentine gradually added whilst stirring the material. Nothing further is required, the varnish is now ready for use. If it is wished to make a thicker kind of varnish, which will cover better, then add only 45 parts of turpentine to 55 of Derna. As long as the varnish is hot it remains in a thin state and only obtains the necessary consistency when cold. If, through being kept too long, the varnish becomes too thick it can be thinned by adding, in a cold state, a

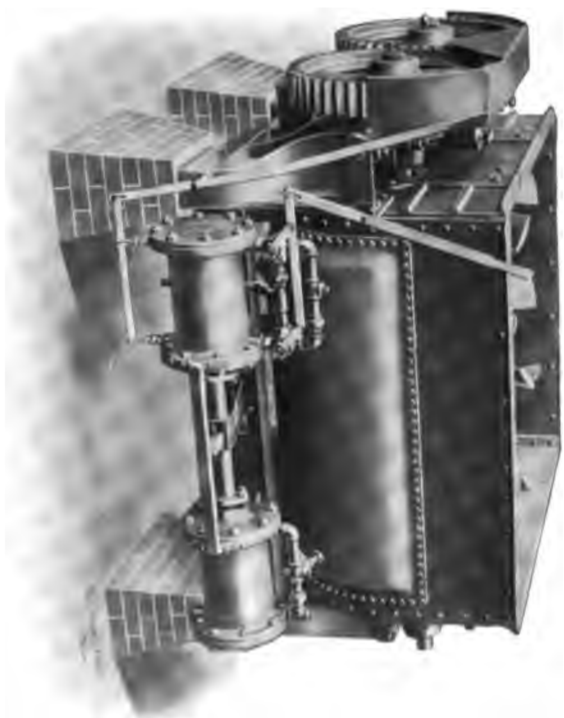
little turpentine. The quality of the varnish depends solely on the class of turpentine used. It is observed further that when using a very hot fire the mineral at times ignites without coming into direct contact with the flames. Care should, therefore, be taken, and appliances held ready, to close as nearly as possible hermetically the boiler in case of the material taking fire. The Hungarian Company use a wrought iron cover and sand to fill any crevices. It does not matter if sand falls into the material as it will sink to the bottom of the boiler and can be removed. During the operation of boiling the material, and mixing it with turpentine, the boiler and vessels used must not be closed.

An important industry is that of cork boards and insulating materials used extensively for breweries, cold storage warehouses and packing houses.

Star Cork Boards are made by the United Cork Companies. They are manufactured from best grade, screened, granulated, natural cork, every granule of which is coated with an odorless, waterproof compound, and compressed into board form. During the entire process the cork is not subjected to extreme heat or great pressure as is the case with othed materials of a similar character. Excessive pressure destroys the cellular structure, and extreme heat destroys the life and vitality of the cork and its insulating properties.

Although cork is practically free from capillarity, they go a little further by using a special asphalt binder, which gives "Star" Cork Board even more insulating value than pure cork, inasmuch as the material they use is absolutely waterproof and impervious to moisture, preventing deterioration and decay. In addition it is highly aseptic and will not decompose nor cause the cork to disintegrate. Gums, glues or cements have no such capacity to resist moisture, and cork board made up with them will not be permanently satisfactory.

"Star" Cork Boards are made 12 inches wide by 36 inches long in any thickness from 1 inch upward. They are squared to accurate dimensions thus making possible tightfitting work with no open joints. The boards can easily be sawed same as lumber to fit uneven o rirregular surfaces, thus further insuring continuous and complete insulation. On account of the compact form of the boards they possess superior structural strength and are adaptable to any construction of building.



ASPHALT MIXER FOR TOPPING AND BINDER.

The electric companies use the material. Fuse works are among its purchasers, and varnish manufacturers all use it in some grade or another, varying from the high-class Egyptian to the cheapest American grades.

One of the most important uses of asphalt not previously referred to is that of the filling of joints of granite and brick pavements. For streets with steep grades granite block with asphalt fillers is the best construction, and such pavement is generally to be found on the piers and heavy traffic streets of European cities. Its advantages for this purpose may be briefly enumerated as follows:

1. It provides for expansion.
2. It provides for contraction.
3. It is absolutely waterproof.
4. It is permanent.
5. Cracks are avoided.
6. It leaves sufficient joints for foothold.
7. It is easy to use correctly.
8. The pavement can be cut without destroying the blocks.

Any of the first-class bitumens will serve this purpose, but some care must be used in discriminating against too highly oxidized material and so-called asphalts produced by "secret process."

Chapter XXV.

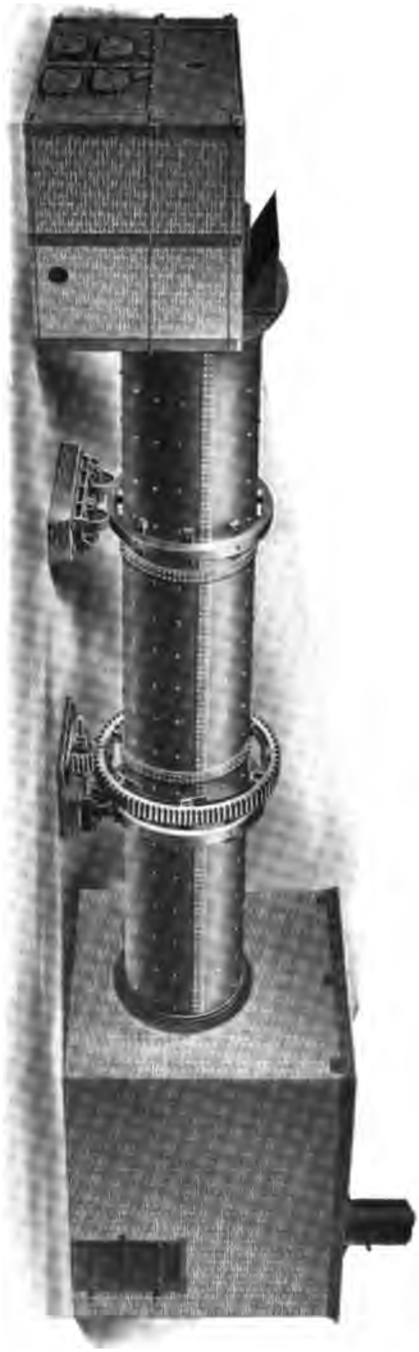
ASPHALT MACHINERY.

MACHINERY naturally enters largely into the asphalt industry, and much expense has been incurred in perfecting various improvements in working plants and refineries. A somewhat recent improvement is a sand dryer, which has been the means of quite a large saving in the cost of paving mixtures for sheet asphalt pavements. This was evolved from suggestions from several asphalt experts by the engineer of the Coatesville Boiler Works. No less than four of these dryers are now in use at the plant of the Cranford Paving Company, Brooklyn. The Filbert Paving Construction Company and Carey & Reed, of Philadelphia, also speak highly of the advantages gained by the use of this machine.

These dryers have been developed during the past few years in the actual work of drying sand and similar materials.

While in a general way they are the cylinder dryer in general use, they have a number of new features which are vitally important to the satisfactory working of these machines, as they are built upon the broad principal of bringing the hottest products of combustion next to the dryest material, which is the reverse from the ordinary sand dryer. This is not only theoretically correct, but it has been found most excellent in actual practice. The drying is more rapidly and thoroughly done and there is practically no dust nor fine material driven from the dryer, owing to the fact that dust or fine aterial picked up by the blast is caught by the fresh material as it enters the dryer.

Then again these dryers are made for hard and constant use. Every portion of the material is what has been found in actual practice to be best for this character of work. At all points where the mechanism is affected by expansion and contraction due to the rapid heating and cooling of the apparatus, provision is made to prevent damage to any part of the structure. As a prominent user has suggested, after four years of constant use, it is a plain, prac-



DIRECT FIRE SAND DRYER, MANUFACTURED BY THE COATESVILLE BOILER WORKS.

tical, substantial machine and as nearly fool proof as a machine can be made.

The shells are made perfectly cylindrical. The tires upon which they rest are steel forging turned all over to insure perfect balance, and these tires are secured to the shll by springs. The same arrangement secures the driving mechanism to the shell. The interior construction is forged steel, so arranged as to be practically indestructible, and the material is dropped through the hot flame and gas from the furnace in a continuous shower, thus subjecting every part of it to the heat in such manner as to dry it evenly and rapidly.

The attachments for the dryer, including blower, blast gates, &c., are so arranged that the operator has absolute control of the temperature at all times.

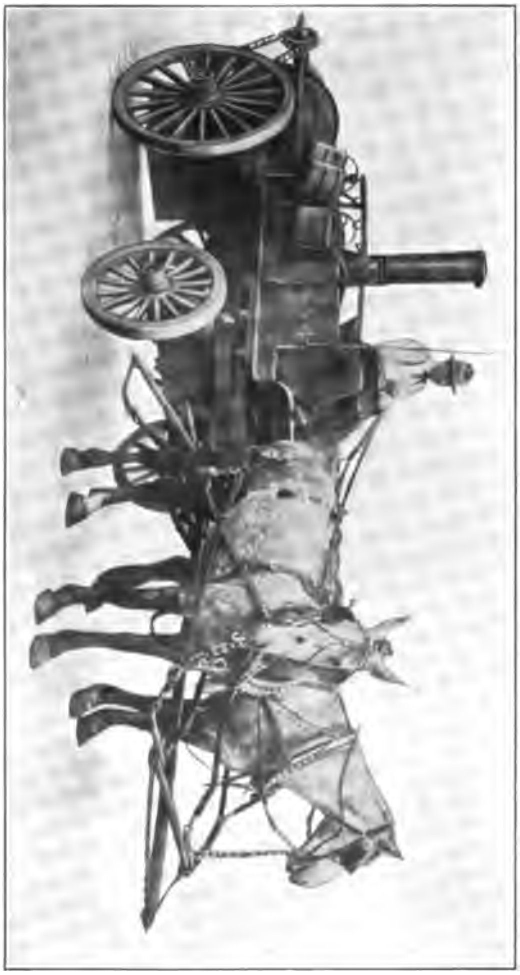
An asphalt plant with a capacity of 1,500 square yards per 9-hour day has been built for the city of Toronto, Ont., by the Warren Asphalt Paving Company, of Boston, at a contract price of $28,575. Its purpose is to enable the city to carry out all repair work promptly and probably lay a few small pavements each year. Complaints have been frequent in the past that openings in asphalt pave-enmts were not promptly repaired, and it is expected that no unreasonable delay will arise hereafter in executing such work. The buildings have steel frames, galvanized roofs and sides, and reinforced concrete floors. The machinery was recently described in a report by City Engineer C. H. Rust as follows:

There are two self-contained rotary driers, manufactured by Warren Asphalt Paving Company, the revolving cylinders being 40 inches in diameter and 19 feet 6 inches long. Draft is supplied by a 50-inch exhaust fan, which discharges into a Cyclone dust collector. The driers are fed by two chain elevators, and the hot sand or stone is discharged into an enclosed elevator and conveyed to steel storage bins holding 10 cubic yards each, situated on the second floor, the stone bin being fitted with a rotary screen. There is also a storage bin for limestone dust provided on the second floor, having a capacity of 4 cubic yards and fed by a dust elevator. The hot material and the dust are drawn by gravity into their respective weighing boxes which discharge into the mixer; the mixer has a capacity of 1,100 pounds of topping mixture.

The asphalt cement is prepared in three enclosed melting tanks provided with mechanical agitation and having a capacity of 2,000

imp. gals. each. The asphalt cement is elevated by air pressure to the asphalt weighing bucket, running on an overhead trolley to the mixer. The storage tank for flux has a capacity of 10,000 imp. gals. The flux is blown from it to the weighing tank on the first floor and drawn by gravity into the kettles.

The asphalt barrels are hoisted to the charging floor by a barrel elevator. Power to the main portion of the plant is supplied by a 10x12-in. engine, manufactured by the Erie Engine Works, and to the agitating tanks and barrel elevator by a 5x5-in. engine, manufactured by the Sturtevant Blower Works. Compressed air for forcing the asphalt cement out of the tanks and other purposes is furnished by a 6x8x12-in. Knowles direct-acting air compressor. Steam is supplied to these engines by a 60-horsepower Star water tube boiler. Street and plant tools, including 8-ton and 5-ton steam asphalt rollers, five wagons, hand rollers, pitch kettles, &c., and twelve Wilkinson asphalt dump wagons, complete the equipment.



SPECIAL WAGON USED BY THE SICILIAN ASPHALT PAVING COMPANY IN CARTING HOT ASPHALT MASTIC.

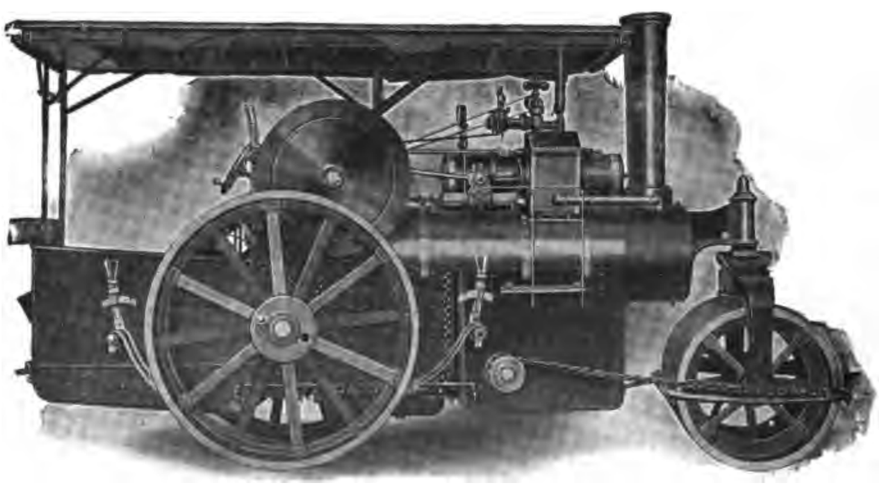
INDEX

INDEX

INDEX.

INDEX.

INDEX OF ADVERTISERS.



Industrial Society for Stone and Earth, Limited

ESCHERSHAUSEN

Registered in Germany as: Industrie-Gesellschaft fur Steine u. Erden, G. m. b. H.

With Asphalt Works in Eschershausen and Holzen, near Vorwohle

Hall of Chemistry, Syracuse University. Laboratory Floors Laid With Magdeburg Asphalt
Over 40,000 Square Feet Laid by the Central City Roofing Co.

Specialties

Crude Asphalt and Crude Powder
Asphalt Mastic
Stamping Asphalt Powder
Asphalt Slabs
Goudrons of every description
Asphalt Cement
Kratolith

GENERAL SALES AGENTS

PRINS & COMPANY :: HAMBURG, GERMANY

For information in the United States, apply to
GENERAL ASPHALT P. S. AGENCY, 39 Pearl Street, New York

H. & A. B. AVELINE & CO.

CATANIA, ITALY

OWNERS OF

Rock Asphalt Mines at Ragusa, Sicily

Asphalt Steam Works

SUPPLY

Rock Asphalt

Rock Asphalt Powder

Rock Asphalt Mastic

Aveline asphalt is admitted by the Italian Government for use in public works.

Highest Award	1882	Messina	Exhibition
" "	1884	Turin	"
" "	1886	Liverpool	"
" "	1893	Chicago	"

Our Rock Mastic Asphalt has for many years been used for streets, footpaths, squares, railway stations, garden walks, courtyards, stables, hospitals, prisons, water closets, barracks, powder magazines, market places, slaughter houses, warehouses, terraces, roofs, porticoes, cellars, foundations, copes of bridges, granaries, kitchens, subpavements, workshops, and for coating walls, tanks and watercourses.

Our Rock Asphalt Mastic is supplied in cylindrical Blocks, weighing about 62 lbs. each, which for identification are stamped

THE ASPHALT CONSTRUCTION COMPANY

Asphalt Paving and General Contracting

Office

207 Broadway, New York

Telephone, 8110 Cortlandt

Plant

137th St. & Madison Ave., New York

Telephone, 771 Harlem